In Vitro, Comparison of the Diagnostic Efficacy of Conventional and Digital Imaging in the Detection of Periapical Lesions

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Abstract:-
Purpose: For more than a century, conventional radiographs have been utilised to assess periapical disease and are still employed in many parts of the world. The application of digital radiography has made a tremendous and widespread impact on diagnostic practice nowadays. Aim of the study was to compare the diagnostic efficacy of conventional and digital imaging in the detection of simulated periapical lesions.

Materials and methods: An in vitro comparative study of digital and conventional intraoral radiographs was conducted using human skull. A total of 5 defleshed cadaver skulls were used in the study in which periapical lesions were created mechanically. Both conventional and digital images were acquired, processed, viewed and assessed for the certainty of the presence or absence of the periapical lesions and the assessment of the scores were done. The results were evaluated using Lickert's scale and finally the assigned scores were compared using Wilcoxon's signed rank test.

Results: The difference between conventional and Dexis digital radiographic methods was found to be statistically not significant, except in the case of mechanically induced periapical lesions created using 4 mm bur, where Digital system outperformed conventional radiography.

Conclusions: Digital radiographic system is considered equivalent to conventional radiography and hence can be routinely used as an alternative to conventional film.

Keywords:- *Conventional radiography; digital radiography; in vitro comparative study; intra oral periapical radiograph.*

I. INTRODUCTION

Dental pulp is a delicate connective tissue that undergoes a consequence of pathologic changes mainly due to caries, mechanical, chemical or thermal sources. The irritation of pulpal tissues results in acute or chronic inflammation in the periapical region. If the irritants are mild and transient in nature, the inflammatory process may be short lived and self-limiting. However, with an excessive quantity of irritants from infected pulp and on persistent exposure to infection, the immunologic reactions can lead to destruction of periapical tissues thus initiating the formation and perpetuation of periapical lesions. A periapical lesion may develop into osteomyelitis, septicemia, Ludwig's angina or even cavernous sinus thrombosis, if not detected and treated.

Diagnosis is the corner stone of treatment for pulpal pathologies. Conventional radiography plays a primary and important role in the diagnosis of periapical inflammatory pathosis. For a long time, radiographic film was the most important medium to acquire and archive the diagnostic image although certain limitations were inherent in the system. The application of digital radiography has made a tremendous and widespread impact on diagnostic practice. Many of the advantages of digital radiography outweigh conventional radiography, many practitioners prefer digital systems. In this background, the study was undertaken to compare the diagnostic efficacy of Digital imaging with that of the Conventional imaging for detecting periapical lesions in vitro.

II. MATERIALS AND METHODS

The study was designed as an in-vitro comparative study. The E-speed plus conventional Intra Oral Periapical (IOPA) film and Dexis Digital Imaging systems were compared for the assessment of periapical lesions in the Department of Oral Medicine and Radiology, College of Dental Sciences, Davangere. A total of 5 defleshed cadaver skulls were included in the study, with atleast 2 posterior teeth (i.e., one on the right quadrant and one on the left quadrant) and an anterior tooth. All those skulls were excluded if all the teeth were missing in any quadrant.

For taking conventional IOPA radiographs E-speed plus intraoral dental films (Ektaspeed Plus Size 2, Eastman Kodak, Rochester, New York), Dental intraoral X-ray machine (Gendex, Italy) with 65 Kilovoltage, 7.5 milliamperes and a timer were used. A well-equipped lightproof dark room with safelight, adequate ventilation and water supply were used for processing the exposed films. The processing tanks consisted of 2 Stainless steel tanks containing developer solution (Kodak D-19 India Ltd.), and fixer solution (Kodak India Ltd.), a master tank provided with water supply, and a manual timer. Dark room was also equipped with a stainless-steel rod to stir the solutions, IOPA film hangers, white adhesive plaster pieces, and a drier provided with heating coil and a fan behind the coil to blow the warm air. For the interpretation of conventional radiographs, an X-ray viewer (X-ray medico surgical engineering ancillary, Madras), black paper, and a magnifying lens were utilized.

The digital radiography, Dexis Digital Radiographic System was used. The system hardware consisted of charge coupled device sensor of 32.0 mm x 25.6 mm x 8 mm dimension with a semiconductor photodiode array made up of 265 x 320 pixels with a resolution of 12.5-line pairs/mm and a PCMCIA (Personal Computer Memory Card International Association) Card with a swap box. This acted as an interface between the sensor and a personal computer and an analogue to digital converter.

A general radiographic survey was done for randomly selected teeth, before any lesion creation, using paralleling cone technique to evaluate any pathologic changes in the periapical area. For the radiographic survey, Dexis charge coupled device detector was used with appropriate x-ray exposure of 65 kVp, 7.5 mA and 0.4 seconds.

IOPA radiographs of randomly selected teeth were taken in the skull, before creating any periapical lesion using digital imaging system with exposure parameters of 65 kVp, 7.5 mA and 0.4 seconds.

The periapical lesions were created mechanically, from the buccal surface of the cortical plate, by drilling the outer cortex, using burs of different sizes perpendicular to the cortical plate, to create various sized lesions in ascending order. Six teeth were selected from each skull for the lesion preparation (Skull 1 - 13, 14, 24, 43, 36 and 45, Skull 2- 23, 14, 25, 32, 36 and 46, Skull 3- 23, 15, 25, 43, 34 and 46 and Skull 4- 12, 14, 25, 33, 36 and 46 and Skull 5 - 23, 14, 25, 43, 37 and 47).

Both conventional and digital images of these lesions (size 0 to size 4) were made (Table 1).

The conventional IOPA radiographs were processed immediately after exposure, using a modified time–temperature method. The procedure was done in a dark room with safe lighting (red GBX – 2 filter fitted 4 feet above the working area). The processing solutions were prepared according to its instruction manual. After processing and drying, radiographs were given unique codes to avoid identification errors. The digital images were immediately displayed and read directly from the monitor.

Steps	Sizes	Stages of lesion preparation
Step I	Size 0	Lesion not created
Step II	Size 1	Lesion created with size 1 bur (1.2 mm)
Step III	Size 2	Lesion created with size 2 bur (2.0 mm)
Step IV	Size 3	Lesion created with size 3 bur (2.6 mm)
Step V	Size 4	Lesion created with size 4 bur (4.0 mm)

Table 1: Stages of periapical lesion preparation

Both digital and conventional images were evaluated for periapical lesions by a single oral radiology specialist with the help of magnifying glass and lesions identified were given appropriate scores using the Lickert scale (Score 1- Definitely present, Score 2- Present, Score 3-Probably present, Score 4- Absent, Score 5- Definitely absent). To improve visualization, black paper cut- outs were used while viewing conventional IOPAs. FDI system was followed for tooth numbering. During the evaluation, only lesions in the periapex were focused and the presence or absence of lamina dura was not considered. Step I radiograph was considered as the gold standard for assessing other radiographs (step II, III, IV and V). Scores for conventional and digital radiographs were given separately, which were entered in a proforma specifically made for the study. The evaluator was asked to view for simulated periapical lesions, for the certainty of the presence or absence of the lesion and was given the following instructions-

- To disregard the presence or absence of the lamina dura and focus their attention strictly on the presence or absence of periapical radiolucencies.
- To consider the step I radiograph, as gold standard for the other radiographs taken at different intervals.

A. *Statistical analysis*

Data was entered in appropriate statistical software for analysis. Summary statistics were expressed in mean +/- standard deviation (numerical score) and Wilcoxon's signed rank test (for comparing numbers & percentages).

B. *Evaluation of Data*

The entire data was entered in the proforma, tabulated, sorted and analysed in the view of aims and objectives of the study.

The conventional and digital radiographs were compared with each other. The difference in the score between conventional and digital radiographic measurements was calculated for each periapical lesion. The mean value of the conventional and the digital measurements are expressed as mean +/- SD and numbers & percentages of these images were compared using Wilcoxon's signed rank test.

C. Wilcoxon's signed rank test:

Ranks were assigned to the differences between digital and conventional measurements. The signs of the differences were retained to ranks assigned.

Sum of the negative (∑ -ve) and positive (∑ +ve) ranks were added separately. Least of the positive and negative sum of the ranks (Index Z) was compared with the table value for significance.

D. Formulas used:

1) $$\text{Mean} = \frac{\text{Sum of all the values}}{\text{Number of values}} = \frac{\sum x}{n}$$

2) $$\text{SD} = \frac{\sum (x - \bar{x})^2}{(n - 1)}$$

III. RESULTS

The study evaluated five defleshed skulls that met inclusion criteria, which were having sufficient number of teeth to be radiographed. A total of 300 radiographs were taken (150 conventional and 150 digital) in the present study. Conventional and Digital radiographs of mechanically prepared periapical lesions were taken at each step and scores were allocated for every radiographs separately (Table 2). Comparison of mean scores of lesions in two imaging systems were visualised in Figure 1.

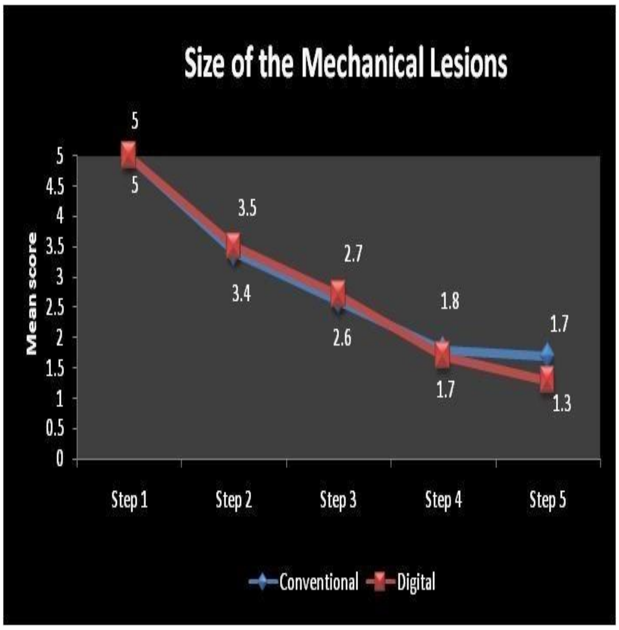

Fig. 1: Comparison of Mean scores of Conventional and Digital imaging at various steps in mechanically prepared periapical lesion

The results in the present study revealed no statistical difference between the conventional and digital radiographs in detecting simulated periapical bone lesions, except in the case of periapical lesions created using 4 mm bur, where Dexis digital system outperformed conventional radiography (Table 3).

In order to compare the mean scores obtained from conventional and digital radiographs in each Step, independent sample t-test was done [t (5) = 0.15, p= .44] and the result was not statistically significant.

Periapical lesions prevail among dental and oral disorders to the point where detecting them is the most important task in everyday practise. In this case, radiographs are the most sensitive and reliable diagnostic tool used by most practitioners.

In terms of diagnostic accuracy, visual enhancement, and reduced radiation exposure, recent advancements in dental radiography technology have made the diagnosis simple and effective. Cone Beam CT has been improved the diagnostic accuracy even further, however it can't be employed in everyday imaging. Conventional radiography are used routinely across several parts of the world and in dentistry schools. Many professors believe that traditional imaging methods will improve diagnosis.

Although digital radiography has come a long way, it still cannot replace traditional radiography in most dental schools, particularly in low and middle-income countries. The key reason for this is the traditional system's cheap upfront and ongoing costs. In addition, conclusive evidence of diagnostic accuracy must be available to replace conventional with digital systems.

There are studies that compare diagnostic efficiency of digital, conventional and ultrasonography for imaging periapical lesions, and found that conventional and digital radiography are dependable for identifying the lesions. However, if the cortical bone is perforated, ultrasonography can best describe the nature of the lesion[1].

Digital radiography technology has advanced to the point that it has become similar in diagnostic efficiency. Ali Mentes *et al* [2], mentioned in their study that linear measurements taken with both conventional and digital techniques are comparable. They used endodontic files to measure the length of root canals from radiographs of curved roots and found no significant difference in canal length between the experimental and control groups.

On evaluation of scores obtained in the present study, mechanically induced lesions by conventional radiographs a total of 26 images were assigned the score 3 compared to that of digital which were 12 images demonstrating uncertainty of presence of lesion or difficulty in interpretation suggesting that digital has superior image quality than conventional images.

Melius *et al* [3] found a significant difference between digital and traditional radiograph measures, with the distance recorded on digital radiographs being 0.1 mm longer than the distance measured on conventional radiography. They also stated that because the endodontic working length will be assessed to the nearest 0.5 mm, this discrepancy will have little clinical impact.

These two radiographic approaches are comparable for detecting caries lesions also. Anbiaee *et al* [4] in 2010 found that for identifying recurrent caries under class II amalgam restorations, digital and conventional bitewing radiographs were of similar diagnostic accuracy.

Lesions with the smallest diameter were not definitely visible in our study. In dry mandibles, the actual size of lesions exceeded the radiographic one. When the x-rays were aimed tangentially at the cortical bone, all lesions were visible on the radiographs. Lesions with the smallest diameter were not visible when the exposure time was prolonged by more than 25% [5]. But sophisticated features in digital imaging can utilize image enhancement and image analyzing tools [6] and this will help to study minute details of bone changes in periapical pathologies.

IV. CONCLUSION

Based on the observations of the study the following conclusions can be drawn

- The quality of the Dexis digital radiographic images is comparable to that of E-speed film for the detection of periapical bone lesions and thus, can be considered to be an equivalent to conventional radiography.
- The Dexis digital radiographic images were little superior to conventional radiographs in our study especially in the case of mechanically induced periapical lesions created using 4 mm bur, which might be due to better efficiency of digital radiography in detecting the larger periapical lesions.
- Dexis digital system can be routinely used in clinical practice as an alternative to conventional method, as it offers many advantages over conventional radiography like instant or real time imaging, reduced radiation, environmental waste reduction, elimination of dark room costs, image transfer and image manipulation facilities.
- Future research may be directed to evaluate the potential clinical benefits of various image enhancement facilities of Dexis digital radiographic system in different periapical lesions.

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Skull No.	Arch	Tooth No.	Scores in Conventional Radiographs					Scores in Digital Radiographs				
			Step I	Step II	Step II	Step IV	Step V	Step I	Step II	Step III	Step IV	Step V
1	Maxillary	13	5	4	4	4	3	5	4	3	3	2
		14	5	4	4	4	4	5	4	4	4	1
		24	5	4	3	3	3	5	4	4	1	1
	Mandibular	43	5	3	2	1	1	5	4	2	2	1
		36	5	4	3	3	3	5	3	2	2	1
		45	5	4	3	3	3	5	2	2	2	2
2	MAX	23	5	4	3	3	3	5	4	4	3	3
		14	5	3	2	2	1	5	4	4	2	1
		25	5	4	1	1	1	5	4	1	3	1
	MAN	32	5	2	1	1	1	5	2	1	1	2
		36	5	4	4	2	1	5	4	3	1	1
		46	5	3	1	1	1	5	4	3	2	1
3	MAX	23	5	4	2	1	1	5	4	3	2	2
		15	5	2	3	1	1	5	2	1	1	1
		25	5	2	2	1	1	5	5	1	1	1
	MAN	43	5	2	2	1	1	5	2	2	2	1
		34	5	4	3	1	1	5	1	1	1	1
		46	5	2	3	2	1	5	2	2	2	1
4	MAX	12	5	3	1	1	1	5	4	2	1	1
		14	5	4	1	1	1	5	4	4	1	1
		25	5	4	4	2	3	5	4	4	1	1
	MAN	33	5	3	3	1	1	5	4	2	1	1
		36	5	4	3	1	1	5	4	2	1	1
		46	5	2	3	1	1	5	4	3	1	1
5	MAX	23	5	4	4	4	4	5	2	2	2	2
		14	5	4	4	2	1	5	5	5	1	1
		25	5	4	4	4	4	5	5	5	3	3
	MAN	43	5	5	2	1	1	5	5	2	1	1
		37	5	4	3	1	1	5	5	5	2	1
		47	5	2	1	1	1	5	1	1	1	1

Table 2: Evaluation of Scores in Mechanically induced Periapical lesions by Conventional and Digital radiographs

Steps	Imaging Modality	Total no. of images	No. of images with score 1 (%)	No. of images with score 2 (%)	No. of images with score 3 (%)	No. of images with score 4 (%)	No. of images with score 5 (%)	Mean score +/-SD	Median score	Conv. Vs Digital	
										$z^{\dagger}$	*p*
Step I	Conv.	30	-	-	-	-	30(100)	5.0+/-0.0	5	0.0	1.0
	Digital	30	-	-	-	-	30(100)	5.0+/-0.0	5		
Step II	Conv.	30	-	7(23.3)	5(16.7)	17(56.7)	1(3.3)	3.4+/-0.9	4	0.62	0.54
	Digital	30	2(6.7)	6(20.0)	1(3.3)	16(53.3)	5(16.7)	3.5+/-1.2	4		
Step III	Conv.	30	6(20.0)	6(20.0)	11(36.7)	7(23.3)	-	2.6+/-1.1	3	0.11	0.91
	Digital	30	6(20.0)	10(33.4)	5(16.7)	6(20.0)	3(10.0)	2.7+/-1.3	2		
Step IV	Conv.	30	17(56.7)	5(16.7)	4(13.3)	4(13.3)	-	1.8+/-1.1	1	0.82	0.42
	Digital	30	15(50.0)	10(33.4)	4(13.3)	1(3.3)	-	1.7+/-0.8	2		
Step V	Conv.	30	21(70.0)	-	6(20.0)	3(10.0)	-	1.7+/-1.1	1	2.24	<0.05*
	Digital	30	23(76.7)	5(16.7)	2(6.7)	-	-	1.3+/-0.6	1		

Table 3: Comparison of Scores Between Conventional and Digital Images In Mechanically Induced Periapical Lesions

$z^{\dagger}$ represents Wilcoxon's signed-rank test
* Statistically significant