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Comparing the Diagnostic Efficacy of Conventional and Digital Imaging Using Chemically Simulated Periapical Lesions

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Introduction

Radiographic imaging is an inevitable modality for diagnosing oral hard tissue lesions. The use of hazardous radiation for imaging is one of its key drawbacks. Despite this, dental radiography is a routine practice in dentistry and oral medicine. This is because of its unreplaceable role in diagnostics. The most practical solution to overcome the ill effects of radiation is to find less injurious imaging options.

Digital imaging has evolved as a less damaging alternative to traditional imaging since it exposes patients to less radiation and produces less biohazardous waste materials. Despite its high cost and significant maintenance requirements, its usage can be pushed on the grounds that it is both environmentally and patient-friendly.

Diagnostic accuracy is the most important criterion to consider when replacing traditional imaging with digital imaging. In general, digital images produced are of inferior quality compared to the conventional technique. We have to identify the margin of error or a safety factor in diagnosing the lesions in digital radiographs. The aim of this in vitro study is to assess the efficacy of digital and conventional imaging in diagnosing oral diseases utilizing the intraoral periapical imaging technique.

Materials and Methods

At the Department of Oral Medicine and Radiology, College of Dental Sciences, Davangere, we carried out a comparative in vitro study. The study was conducted on defleshed cadaver skulls after chemically creating periapical lesions in them, which were then imaged using both conventional IOPA film and Digital imaging systems using paralleling technique. The study began after getting approval from the Institutional Research Committee. Since this was an in vitro study and there was no harm to the living systems, no ethical problems were faced. Radiographic wastes were managed properly according to institutional protocols.

Only those skulls with at least two posterior teeth (one on the right and one on the left quadrants) and an anterior teeth were included in the study. Edentulous skulls were excluded from the study. For taking conventional radiograph, Ektaspeed Plus Size 2 Intra Oral Periapical Film (Eastman Kodak, Rochester, New York) and Dental intraoral X-ray machine (Gendex, Italy; 65 kVp, 7.5 mA) were used. A well-equipped dark room complemented the accurate imaging procedure. The digital radiographic system used was 'Dexis Digital Radiographic System' (65 kVp, 7.5 mA). The Intra Oral Periapical(IOPA) radiographs were taken using paralleling cone technique.

In each skull, 6 teeth were selected for chemically induced periapical lesions among which 3 teeth were maxillary and 3 teeth were mandibular. The teeth included in the skull 1 were 23, 17, 27, 32, 37 and 46, where as in the skull 2, the teeth included were 13, 15, 27, 33, 37 and 47, in the skull 3, the teeth included were 13, 14, 24, 33, 35 and 45, in the skull 4, the teeth included were 13, 15, 24, 43, 34 and 44 and in the skull 5, the teeth 12, 15, 24, 32, 36 and 46 were included.

The periapical lesions were created chemically, from the buccal surface of the cortical plate, by drilling a vertical or oblique groove which was made to the apex of the roots of various teeth. 50% nitric acid was then injected into the depth of the grooves to create chemically induced periapical lesions. Both conventional and digital images were made for chemical lesions at 0 hour, 24 hrs, 48 hrs, 72hrs and 96 hrs.

Radiographs taken at various steps:

Step I - lesion not created

Step II - lesion created and reviewed after 24 hrs

Step III - lesion reviewed after 48 hrs

Step IV - lesion reviewed after 72 hrs

Step V - lesion reviewed after 96 hrs

After in vitro lesion preparation, IOPA radiographs were taken using conventional and digital methods using paralleling technique (**Figure 1**).

Figure 1: Procedure for imaging maxillary and mandibular teeth

All the films were processed manually using modified time-temperature method, in a well-equipped light proof, dark room under safe light of low intensity and long wave length (red) using red GBX - 2 filter fitted 4 feet above the working area. The processing solutions were prepared and used according to the manufacturer's directions.

The conventional radiographs that were processed were coded to make film appraisal easier. Black paper cut-outs were prepared and the films were mounted in the cut-outs on the viewer. After exposure, the digital images were immediately displayed on the monitor. The images were numbered for identification and were evaluated with appropriate score using Lickert's scale (Score 1- Definitely present, Score 2- Present, Score 3- Probably present, Score 4- Absent, Score 5- Definitely absent). Using magnifying glass, the presence of periapical lesions in both conventional and digital images were identified and given appropriate score using Lickert's scale, separately for chemical and mechanical lesions. FDI tooth numbering system was followed for easy description and standardization of the results. All the measurements and relevant data were entered in a pre-designed proforma.

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 +/- standard deviation and numbers & percentages of these images were compared using Wilcoxon's signed rank test.

Results

In the present study, five defleshed skulls were included with two posterior teeth (i.e., one on the right quadrant and one on the left quadrant) and an anterior tooth. Both conventional and digital radiographs were compared for chemically induced periapical lesions from step I to step V and scores were given.

Evaluation of scores by conventional radiographs:

In Step I, all the teeth in the 5 defleshed skulls included in the study were assigned a score of 5. In Step II, 3 teeth were assigned a score of 5, 21 teeth with a score of 4, 5 teeth with a score of 3, and 1 tooth with a score of 2. In Step III, 13 teeth were assigned a score of 4 and 3, and 4 teeth with a score of 2. In Step IV, 10 teeth were assigned a score of 4, 16 teeth with a score of 3, 3 teeth with a score of 2 and 1 tooth with a score of 1. In Step V, 7 teeth were assigned a score of 4, 15 teeth with a score of 3, 5 teeth with a score of 2 and 3 teeth with a score of 1.

Of the above observations, in Step II, 3 teeth were assigned a score of 5 which revealed that definite absent of the lesion eventhough when the lesion was created. This could be due to inferior image quality obtained using conventional radiographs.

Evaluation of scores by digital radiographs:

In Step I, all the teeth in the 5 defleshed skulls included in the study were assigned a score of 5. In Step II, 1 tooth was assigned a score of 5, 27 teeth with a score of 4, and 2 teeth with a score of 3. In Step III, 17 teeth were assigned a score of 4, 9 teeth with a score of 3, and 4 teeth with a score of 2. In Step IV, 11 teeth were assigned a score of 4, 14 teeth with a score of 3, and 5 teeth with a score of 2. In Step V, 6 teeth were assigned a score of 4, 15 teeth with a score of 3, 7 teeth with a score of 2 and 2 teeth with a score of 1.

Of the above observations, in Step II, 1 tooth was assigned a score of 5 which revealed that definite absent of the lesion even though when the lesion was created. This could be due to inferior image quality obtained using digital radiographs.

The comparison of scores between conventional and digital images in chemically induced periapical lesions in all the 5 steps were given in **Table 1**.

Table 1: Comparison of Scores Between Conventional and Digital Images in Chemically Induced Periapical Lesions

Steps	Imaging Modality used	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	Conventional Vs Digital	
										z*	p
Step I	Conventional	30	-	-	-	-	30(100)	5.0+/-0.0	5	0.0	1.0
	Digital	30	-	-	-	-	30(100)	5.0+/-0.0	5		
Step II	Conventional	30	-	1(3.3)	5(16.7)	21(70.0)	3(10.0)	3.9+/-0.6	4	0.71	0.48
	Digital	30	-	-	2(6.7)	27(90.0)	1(3.3)	4.0+/-0.3	4		
Step III	Conventional	30	-	4(13.3)	13(43.3)	13(43.3)	-	3.3+/-0.7	3	0.68	0.50
	Digital	30	-	4(13.3)	9(30.0)	17(56.7)	-	3.4+/-0.7	4		
Step IV	Conventional	30	1(3.3)	3(10.0)	16(53.3)	10(33.4)	-	3.1+/-0.8	3	0.21	0.83
	Digital	30	-	5(16.7)	14(46.7)	11(36.7)	-	3.2+/-0.7	3		
Step V	Conventional	30	3(10.0)	5(16.7)	15(50.0)	7(23.3)	-	2.9+/-0.9	3	0.07	0.94
	Digital	30	2(6.7)	7(23.3)	15(50.0)	6(20.0)	-	2.8+/-0.8	3		

z* represents Wilcoxon's signed rank test

Figure 2 shows a detailed comparison of mean scores at various levels in the radiograph, with both traditional and digital techniques.

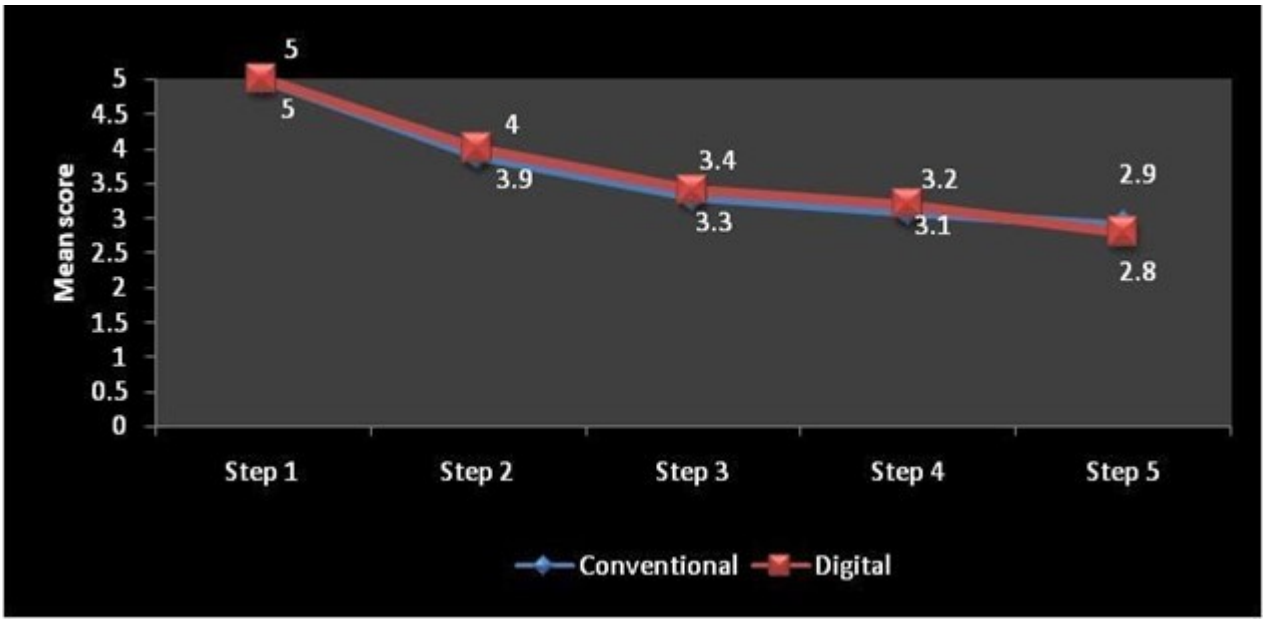

Figure 2: Comparison of mean scores of conventional and digital imaging at various steps in chemically prepared lesion

The results in the present study revealed no statistical difference between the conventional and digital radiographs in detecting simulated periapical bone lesions.

Discussion

The present study was undertaken to compare the diagnostic performance of Dexis digital radiographic system with that of conventional radiographic system for assessment of periapical lesions in vitro. A total

of 300 lesions in 5 skulls were evaluated using conventional and Dexis digital radiographic methods.

Lesions created chemically were not detectable or difficult to interpret in few radiographs and this could be due to the chemical used in our study. The concentration of Nitric acid in the present study was 50% in contrast to other studies, where they have used 70% concentrated perchloric acid and pooling of the acid was done by the preparation of wax blocks. Moreover, in our study, the buccal cortical plate was selected for lesion creation, in contrast to the other studies where they have sectioned and created lesions exactly at the periapical region [1].

In our study, the lesions overlap the vertical drill created for acid insertion as compared to simulated periapical lesions created within the tooth socket at selected time intervals, which showed more realistic radiographic appearance by preventing the creation of sharp edges at the lesion borders [1].

Digital enhancement was not used in our study in contrast to the study conducted by Yokota et al who found that the RVG enhancement linear setting to be more diagnostically significant in the detection of chemically created lesions [2].

On evaluation of scores of chemically induced lesions by conventional radiographs a total of 49 images were assigned the score 3 compared to that of digital which were 40 images demonstrating uncertainty of presence of lesion or difficulty in interpretation suggesting that digital has superior image quality than conventional images.

One of the reasons for uncertainty of presence of lesion or difficulty in interpretation is various anatomical structures in the path of radiation. Superimposition of different anatomic structures impedes the detection of small changes in bone density. Difficulty in interpretation may also be probably due to difficulties in image capturing or exposure due to anatomical structures, errors in processing of the film and difficulties in interpretation due to false positive lesion and mineral content per unit volume of bone [3].

Another reason may be due to changes in angulations of the x-ray beam. A decrease in vertical angulation produced an elongated tooth with a subsequent increase in the size of the radiolucent area, whereas, an increase in vertical angulation produced a foreshortened tooth with a subsequent decrease in the size of the radiolucent area. Wengraf et al showed that a difference of 15 degrees in the horizontal angulation often discloses a region of rarefaction, although, a change in the vertical plane is not significant in detecting a radiolucent area.

Few radiographs in our study showed probable absence of the lesion on film which may be due to a change in angulation in the x-ray or a change in position of the teeth. The percent of mineral loss within the path of the central x-ray beam perpendicular to the object is the critical aspect. From one angle, more calcified tissue is picked up within the path of the x-ray beam and gives the impression of increasing bone thickness or mineral content. From another angle the radiograph gives the impression of decreasing bone thickness or subtracting mineral. Thus, because of the curvilinear nature of the mandible with the variations in compactness and thickness, different x-ray angulations are essential to improving diagnostic acumen [4].

Wallace et al found that conventional radiography outperforms the digital system, when observers could manipulate image characteristics [5]. Paurazas et al [6], and Versteegersteeg et al [7] showed that there was no statistical significance between conventional and digital radiography. Tyndall et al [8] found in a particular study, when no lesions existed conventional radiographs were more diagnostic than RVG, when lesions are enlarged to involve lamina dura and medullary bone, RVG is superior and no difference is found between conventional and RVG, when the mechanical lesions involve cortical bone.

Conversely, the present study revealed no statistical difference between the conventional and digital radiographs in detecting simulated periapical bone lesions, except in the case of mechanically induced periapical lesions created using 4 mm bur, where Dexis digital system outperformed conventional radiography. There are studies which demonstrated that digital and conventional bitewing radiographs were equally efficient in detecting recurrent caries under class II amalgam restorations [9].

The digital radiographs were little superior to conventional radiographs in our study, which might be due to better efficiency of digital radiography in detecting the larger periapical lesions. This indicates that the Dexis system can be suitable for routine use in clinical assessment of periapical lesions.

Conclusions

The following conclusions can be made from the present study: The quality of the 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 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.

Conflicting Interest: The authors report no conflict of interest

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