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Dentistry Section

Original Article

A Comparative Study on Diagnostic Accuracy of Colour Coded Digital Images, Direct Digital Images and Conventional Radiographs for Periapical Lesions – An In Vitro Study

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ABSTRACT

Objectives: The identification and radiographic interpretation of periapical bone lesions is important for accurate diagnosis and treatment. The present study was undertaken to study the feasibility and diagnostic accuracy of colour coded digital radiographs in terms of presence and size of lesion and to compare the diagnostic accuracy of colour coded digital images with direct digital images and conventional radiographs for assessing periapical lesions.

Materials and Methods: Sixty human dry cadaver hemimandibles were obtained and periapical lesions were created in first and second premolar teeth at the junction of cancellous and cortical bone using a micromotor handpiece and carbide burs of sizes 2, 4 and 6. After each successive use of round burs, a conventional, RVG and colour coded image was taken for each specimen. All the images were evaluated by three observers. The diagnostic accuracy for each bur and image mode was calculated statistically.

Results: Our results showed good interobserver (kappa > 0.61) agreement for the different radiographic techniques and for the different bur sizes. Conventional Radiography outperformed Digital Radiography in diagnosing periapical lesions made with Size two bur. Both were equally diagnostic for lesions made with larger bur sizes. Colour coding method was least accurate among all the techniques.

Conclusion: Conventional radiography traditionally forms the backbone in the diagnosis, treatment planning and follow-up of periapical lesions. Direct digital imaging is an efficient technique, in diagnostic sense. Colour coding of digital radiography was feasible but less accurate however, this imaging technique, like any other, needs to be studied continuously with the emphasis on safety of patients and diagnostic quality of images.

Keywords: Conventional radiography, Digital radiography, Periapical lesions

INTRODUCTION

In the last two decades, digital radiography has gained popularity as alternative to conventional radiography, as it has given the dentist the ability to perform radiographic examination with a significant reduction in radiation exposure up to 50% - 80% [1]. There are other advantages such that images may be manipulated digitally after the event of exposure for size (zoom), contrast and density and special effects such as edge-detection, smoothing and false colour, as well as quantitative measurements, can be achieved [2].

Recently, colour coding has been proposed as a means of detecting differences between sequential images. Colour image displays may be superior to achromatic or monochromatic display in as much as they provide a perceptual dimension that enhances observer information processing and heightens the ability to interpret different types of data present in a particular image [3]. In theory, the human visual system is more sensitive to differences in colour than to differences in gray levels in black-and-white images [4]. This implies that diagnostic information should be more perceptible in a coloured than in a gray scale conventional radiograph, and that a colour-coding method used to replace the gray scale would be beneficial.

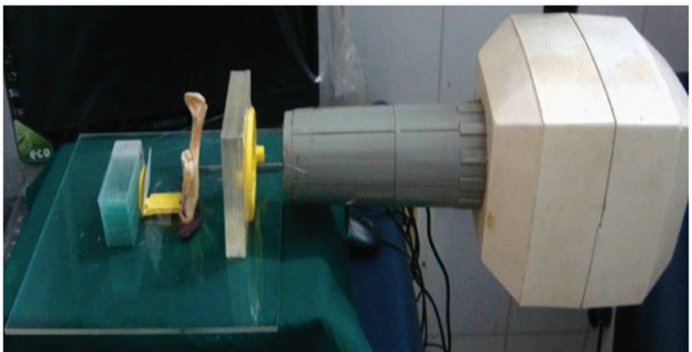
However, in literature, limited studies have been conducted on the diagnostic accuracy and feasibility of colour coding the digital radiographs in the assessment of periapical lesions.

Hence, a need was felt to compare the feasibility and diagnostic accuracy of colour coded digital radiographs in terms of presence and size of periapical lesions with conventional and direct digital images in assessment of periapical lesions.

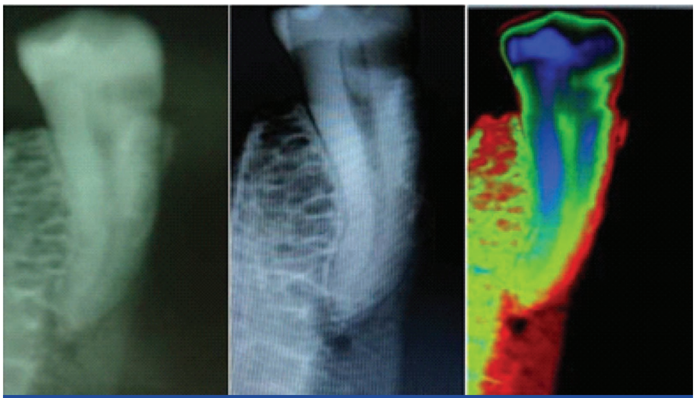
MATERIALS AND METHODS

This in-vitro study was conducted on 60 dry human cadaver hemimandibles at the periapical region of 1st and 2nd premolar teeth with no preexisting periapical pathosis.

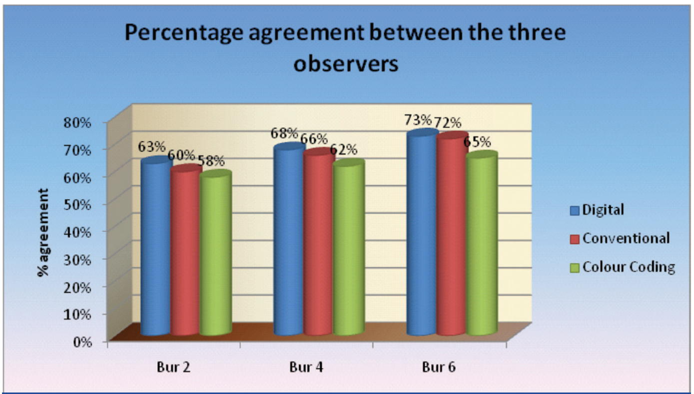
The selected dry mandibles were sectioned vertically to include the area between canine and molar region. A bone hack saw and a carborundum disk mounted on a slow speed micromotor straight hand-piece were used to section the jaws. Care was taken to avoid involving the peri-radicular areas of the teeth to be studied. Conventional radiographs of these sections were taken to determine the presence of any pre-existing periapical pathosis. Only those sections in which there was no preexisting periapical pathosis were included in the study.



[Table/Fig-1]: Mounting platform for taking periapical lesions



[Table/Fig-2]: Images with taken with conventional, digital and colour coding radiography with periapical lesions



[Table/Fig-3]: Percentage agreement between the observers for detectability of periapical lesions with different bur sizes

Periapical lesions were created at the junction of cancellous and cortical bone using a micromotor handpiece and carbide burs of sizes 2, 4 and 6 placed in succession to the depth of the bur head into the previous hole. A total of 180 conventional, 180 RVG and 180 colour coded images were made with constant time settings of 0.25 seconds. Conventional radiographs used were Size 2 E-speed intraoral dental films (Ektaspeed size 2, Eastman-Kodak Co, Rochester, NY, USA). Dental X-Mind intraoral X-ray machine with 65 Kilo voltage peak, 8 milliamperes (Satelec India Pvt Ltd, Acteon Group, Hague, Netherlands. RVG sensor used was Kodak RVG 5100.

Each mandibular section was mounted on a block of silicon paste on a one inch thick plexiglass base. A soft tissue substitute was made with ten 4x4 inch plexiglass of 25mm. Onto this section of plexiglass a Rinn XCP (Dentsply/Rinn Corp, Elgin, Ill) paralleling device was centered. A constant source to object distance was maintained at 4.5 cm. A constant object-to-film distance was maintained of 2.5 cm [Table/Fig-1].

Evaluation of radiographs was conducted by three observers, which included one endodontist and two oral radiologists. The observers were asked to indicate their certainty with each study specimen by using the following Lickert scale.

1- Lesion definitely present.

2- Lesion probably present.

3- Uncertain whether lesion is present.

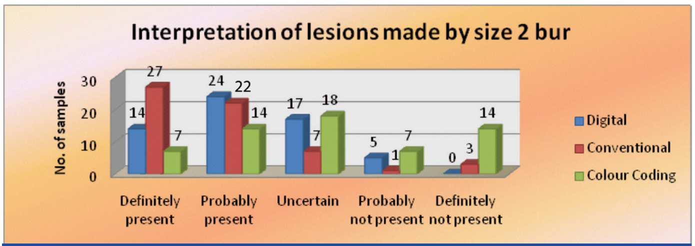
4- Lesion probably not present.

5- Lesion definitely not present.

The evaluators were instructed to disregard the presence or absence of the lamina dura and focus their attention strictly on the presence or absence of periapical radiolucency. The measurements were made on the digital and colour coded images through use of a mouse driven cursor to an accuracy of 0.1mm. Lesions were measured on radiographs to the nearest 0.5mm [Table/Fig-2].

Bur 2	Method			Total	χ^2	P-Value
	Digital	Conventional	Colour Coding			
Definitely present	14	27	7	48	44.445	<0.001*
Probably present	24	22	14	60		
Uncertain	17	7	18	42		
Probably not present	5	1	7	13		
Definitely not present	0	3	14	17		
Total	60	60	60	180		

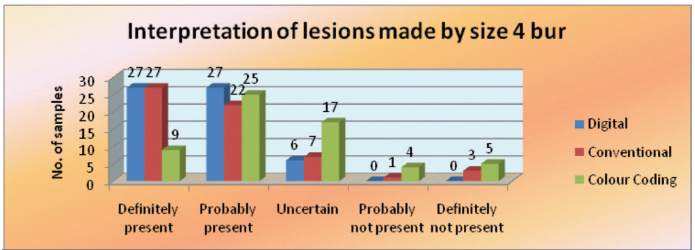
[Table/Fig-4]: Table showing interpretation of periapical lesions made with bur 2 diagnosed with each technique



[Table/Fig-5]: Interpretation of periapical lesions made with size 2 bur

Bur 4	Method			Total	x²	P-Value
	Digital	Conventional	Colour Coding			
Definitely present	27	27	9	63	28.149	<0.001*
Probably present	27	22	25	74		
Uncertain	6	7	17	30		
Probably not present	0	1	4	5		
Definitely not present	0	3	5	8		
Total	60	60	60	180		

[Table/Fig-6]: Table showing interpretation of periapical lesions made with bur 4 diagnosed with each technique



[Table/Fig-7]: Interpretation of periapical lesions made with size 4 bur

STATISTICAL ANALYSIS

The data obtained were analysed using the Statistical Package for the Social Sciences (SPSS) for Windows (Chicago, IL). The interobserver reliability for measuring the dimensions of periapical lesions was analysed using analysis of variance (ANOVA).

The interobserver agreement for diagnosing the periapical lesions was analysed using the kappa statistics. Chi square test was used to find the significance between the lesion presence and the detection method. The diagnostic accuracy for each bur and image mode was calculated as the areas under receiver operating characteristic (ROC) curves.

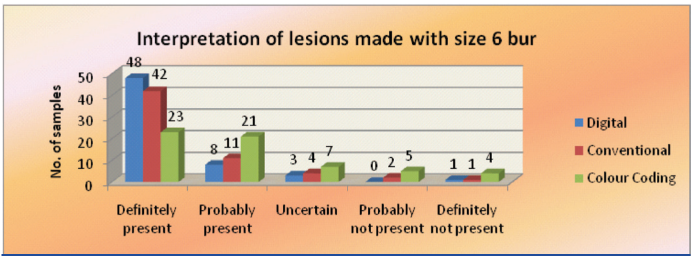
RESULTS

Our results showed that the percentage agreement between the observers for periapical lesions made with different size burs was more in direct digital images than in conventional and colour coding method [Table/Fig-3].

Cohen's kappa measures the agreement between the evaluations of observers when they are observing the same object. These values give the kappa measure to determine interobserver reliability. All the

Bur 6	Method			Total	x^2	P-Value
	Digital	Conventional	Colour Coding			
Definitely present	48	42	23	113	26.280	0.001*
Probably present	8	11	21	40		
Uncertain	3	4	7	14		
Probably not present	0	2	5	7		
Definitely not present	1	1	4	6		
Total	60	60	60	180		

[Table/Fig-8]: Table showing interpretation of periapical lesions made with bur 6 diagnosed with each technique



[Table/Fig-9]: Interpretation of periapical lesions made with size 6 bur

Conventional	Observer 1	Observer 2	Observer 3	p-value
Bur 2	0.42mm±0.24	0.41mm±0.22	0.44mm±0.64	0.917
Bur 4	0.68mm±0.34	0.70mm±0.49	0.67mm±0.36	0.947
Bur 6	1.5mm2±0.57	1.52mm±0.56	1.53mm±0.58	0.967
Digital	**Observer1**	**Observer 2**	**Observer 3**	**p-value**
Bur 2	0.44mm±0.25	0.41mm±0.21	0.42mm±0.24	0.789
Bur 4	0.89mm±0.34	0.87mm±0.32	0.89mm±0.41	0.931
Bur 6	1.73mm±0.45	1.73mm±0.40	1.75mm±0.48	0.951
Colour coding	**Observer1**	**Observer 2**	**Observer 3**	**p-value**
Bur 2	0.17mm±0.16	0.17mm±0.16	0.18mm±0.17	0.989
Bur 4	0.48mm±0.27	0.48mm±0.44	0.50mm±0.32	0.896
Bur 6	0.86mm±0.56	0.85mm±0.64	0.86mm±0.73	0.981

[Table/Fig-10]: Mean lesion size recorded by the three observers using conventional, digital and colour coding technique using the three different bur sizes

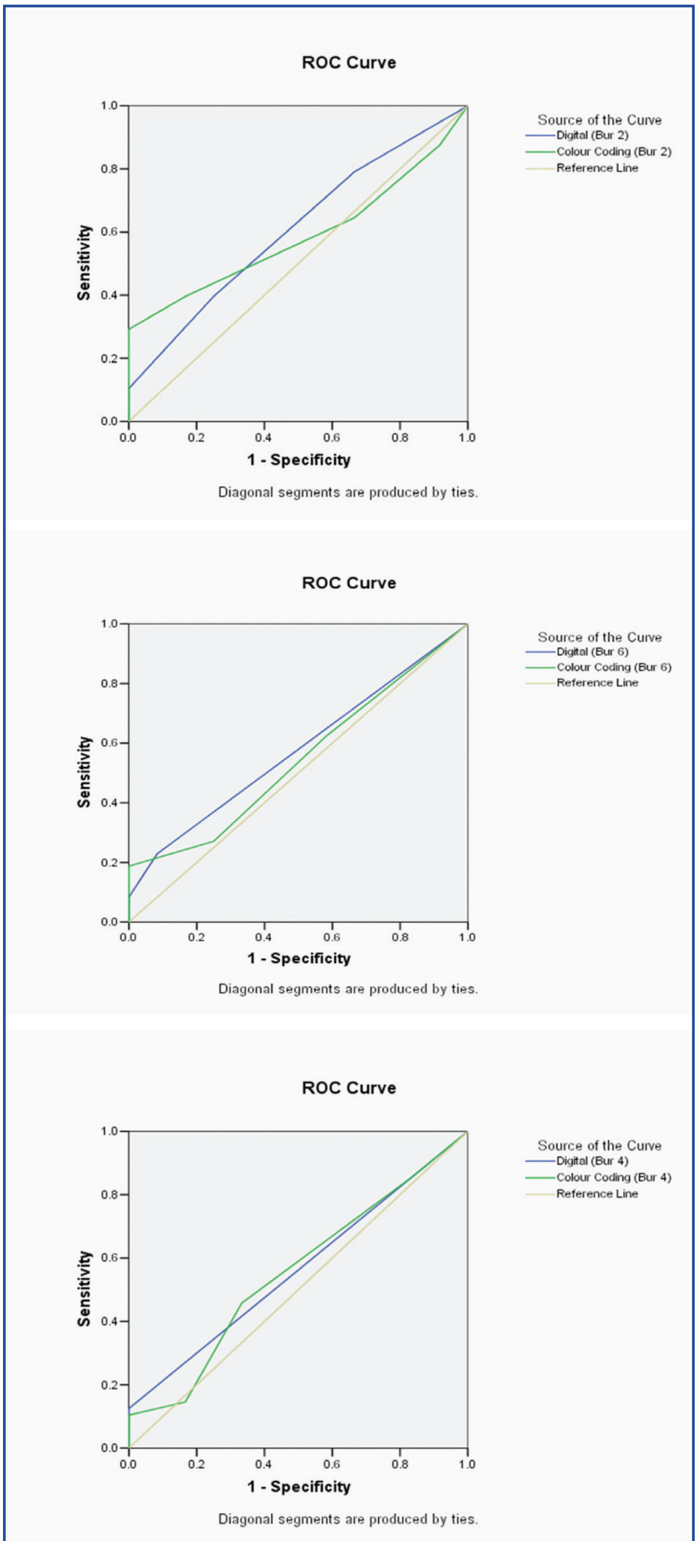
three methods shows good agreement between the observers as the value is more than 0.61.

Out of 180 periapical lesions interpreted for size 2 and 4 bur, Conventional method was found to detect more number of lesions interpreted with size 2 bur followed by digital method. There was a significant association (p-Value <0.001) between the lesion presence (for size 2, 4 and 6 bur) and the detection method [Table/Fig-4&5], [Table/Fig-6,7], [Table/Fig-8,9]. Colour coding method was found to detect the least number of periapical lesions for all the bur sizes.

The mean lesion size for the periapical lesions interpreted by all the observers for all the burs sizes is shown in the table below [Table/Fig-10].

These results infer that the difference in mean lesion size between the three observers was not statistically significant for all the bur sizes (2, 4 and 6).

The diagnostic accuracy was also evaluated with the Receiver Operating Characteristic (ROC) analysis technique. The value of the probability of accuracy was measured by Receiver Operating Characteristic Curve and these were obtained using SPSS software (Appache Software Foundation, U.S.A). The graph generated by the ROC curve calculates the P (A) values for each bur and for digital and colour coding technique and the mean of all P (A) values, which it serves as the value of accuracy for each technique in diagnosing the periapical lesion [Table/Fig-11]. In the present study the area under the curve was more for digital technique than colour coding method



[Table/Fig-11]: The area under the curve shows more area with the digital technique when compared to colour coding technique which signifies that digital method is better than colour coding technique for diagnosing periapical lesions made with size 2, 4 AND 6 BUR

which infers the diagnostic accuracy of digital and conventional radiography is better than colour coding method.

DISCUSSION

The most reliable way to assess the outcome of a new imaging method is to compare its ability to reveal pathological changes with the true state of the object. In a clinical study this is, however, most often impossible for ethical reasons. Since periapical bone lesions are difficult to simulate, clinical studies are still important in the evaluation of new imaging techniques. Another way to assess the outcome of a new imaging method clinically is to compare its ability to detect bone changes with a reference standard. In the present study this standard consisted of the readings presented by expert observers and results obtained with the conventional imaging method [5].

The variations associated with reading and interpreting radiographic images is a factor contributing to the diagnostic accuracy of identifying bony lesions. Van der Stelt outlined several shortcomings affecting the interpretation of images, including limitations of the human eye, optical illusions, cognitive processing of visual information, and biasing that may occur because of expectations or prior knowledge. These factors can lead to images being misinterpreted. No matter how great an effort is made to randomize the images presented, there is a certain amount of learning that occurs during the observations; as a result, an image can be retained in the observer's memory and compared with images that are subsequently viewed. However, learning that occurs may not necessarily be a significant factor affecting the overall results, because it is likely to occur among all observers as a result of the nature of the process [6].

In our study the interobserver agreement varied between 60% to 72%, for conventional method, 63% to 72% for digital method and 58% to 65% for colour coding method which shows good interobserver agreement. Our results were similar to Tirell et al., [7] who found a very high interobserver agreement of 85.6%. Saunders et al., [8], in contrast to our results, found that interobserver agreement was poor in CR, despite strategies attempting to improve reproducibility, such as observer calibration, strict criteria, and scoring indices.

The interobserver reliability calculated by kappa shows higher interobserver agreement in DDR as compared to CR and least in colour coding. It is a well-known fact that perceptual learning has a great impact on extracting information from any type of images and the decreased agreement in colour coding may be due to the fact that colour-coded radiographs may decrease the perception threshold of the observers to some extent [9].

As per studies by Tirell et al., and Yokota et al., and RVG outperforms the conventional radiography in the diagnosis of initial periapical lesions [7,10]. This was in contrast to our study where we found that out of 180 periapical lesions interpreted with size 2 bur, lesions definitely present were 48 out of which 27 were detected with conventional method, 14 with digital method and 7 with colour coding method. However, similar numbers of definitely diagnosed lesions were found with conventional and digital radiography when the lesion size were interpreted with size 4 bur. Lesions interpreted with larger bur size (size 6) were detected by greater accuracy than lesions interpreted with smaller burs (size 2 and size 4). For periapical lesions interpreted with size 6 bur, digital method detected more number of periapical lesions than conventional method and least number of lesions were detected with colour coding method which was in accordance with other studies [7,10].

This suggests that a larger volume of bone destruction is required for the perception of periapical radiolucency. Our results were similar to studies conducted by Tirell et al., Barbat J et al., and Sullivan J E et al., who found that the quality of the direct digital images was comparable to that of E speed film for the detection of periapical bone lesions and digital radiography did not enhance the overall diagnostic accuracy of periapical lesions and there were no significant differences with the various RVG enhancement settings used [7,11,12].

In the present study the comparison of measurements recorded by three observers using conventional, digital and colour coding method was done in which no statistically significant difference was observed between the three observers for determining the mean lesion size for all the bur sizes. A possible explanation may be that perception in colour-coded radiographs might be underestimated owing to the fact that the observers were used to viewing conventional gray scale radiographs but had no previous training in viewing colour-coded radiographs.

The results of the present study supports those prior studies of Paurazas et al., [6], Holtzmann et al., [13] and Mistak et al., [14], and where in no difference in diagnostic accuracy between CR and DDR techniques were found in diagnosing periapical lesions. In many previous studies image enhancement techniques have been performed to improve the diagnostic accuracy. The conclusions of these studies are not uniform, rather they are divided. In our study colour coding of digital radiography was used as an enhancement feature which was found to be diagnostically less accurate. Similar results were shown by Kullendorff et al., where they reported deterioration of diagnostic accuracy by digital image enhancement [5]. Gang et al., found out that colour coded digital radiographs did not provide a more favourable accuracy when assessing marginal bone levels [4]. In contrast, several studies have shown that digital contrast enhancement and filtering may increase diagnostic accuracy [15]. This may be due to the fact that one may encounter colour coding of radiographs that looks highly arbitrary as regards to hue ordering and too much exaggerated as regards to brightness and saturation, of the colours to be satisfactory evaluated. In such cases, the colour coding does not bring about any improvement in the legibility of the radiographic information. Since the gray scale is accepted in interpretation and has worked well so far, colour coding should be used to emphasize and improve the interpretation rather than subdue the utility of gray scale images [16].

One limitation in our study was that radiographic images were displayed and assessed on a view box and digital images were viewed on a computer monitor, the type of image being viewed was obvious. This could account for potential bias that an observer might have toward one type of imaging technique in preference to another.

CONCLUSION

Improvement of image quality by image manipulation, and automated analysis of digital images may contribute to better radiodiagnosis. Direct digital imaging is an efficient technique, in diagnostic sense. Colour coding of digital radiography was feasible but less accurate however, this imaging technique, like any other, needs to be studied continuously, with the emphasis on safety of patients and diagnostic quality of images. Since the gray scale has worked well in radiography during a long period of time, it is not the intention that the suggested colour scale should be used to substitute the gray scale in ordinary radiographic work. Instead, the colour scale may be used as an approach to enhance radiographic information for certain diagnostic purpose. Further studies are required which will focus on the application of this colour coding method for different diagnostic tasks.

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