Section: Pediatrics

Original Research Article

COMPARISON OF CONVENTIONAL RADIOGRAPHIC METHOD WITH DIRECT DIGITAL RADIOGRAPHIC METHOD IN DETECTING INTERPROXIMAL CARIES

Yogita Idhate[1], Tushar Idhate[2]

[1]Assistant Professor, Department of Dentistry, MGM Medical College and Hospital, MGM University, Chhatrapati Sambhaji Nagar, Maharashtra, India
[2]Assistant Professor, Department of Pediatrics, MGM Medical College and Hospital, MGM University, Chhatrapati Sambhaji Nagar, Maharashtra, India

Received : 03/11/2023
Received in revised form : 04/12/2023
Accepted : 17/12/2023

Keywords:
Conventional radiography, digital radiography, Dental caries, bitewing radiograph, proximal carious.

Corresponding Author:
Dr. Tushar Idhate,
Email: tusharidhate@gmail.com

DOI: 10.47009/jamp.2023.5.6.187

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (6); 909-915

Abstract

Background: Dental caries is a progressive, irreversible, microbial disease leading to cavity formation. Radiography is a vital adjunct for diagnosing caries that detects 30- 70% more proximal caries than a clinical examination alone. Conventional intraoral radiographic examination has its greatest value in the detection of proximal carious lesions that are not easily detectable by careful and thorough clinical examination. Digital systems provide facilities for image manipulation. The present study was undertaken to compare conventional radiography with digital radiography in the detection of proximal caries. **Materials and Methods:** The present prospective was conducted amongst 350 subjects of which 158 were males and 192 were females between March 2018 and March 2020. Each patient was subjected to two Conventional Radiographs, including periapical and bitewing radiograph and two Digital Radiographs, including periapical and bitewing radiographs of the same region in which proximal caries was suspected. **Result:** The subjects enrolled were 350 with 350 clinically suspected carious surfaces as the study group and 1750 adjacent surfaces which clinically were not suspected with caries as the control group. Of the 350 subjects, 158(45.14%) were male and 192(54.86%) were female. The mean age of 350 subjects was 36.96±12.28 years. A comparison of conventional radiographic diagnosis with the digital radiographic diagnosis for the detection of proximal caries revealed no statistically significant difference and both were comparable. Comparison of grading of caries on conventional and digital radiographs also confirmed that conventional radiography methods are comparable with digital methods. **Conclusion:** We conclude from the present study that although there was no statistically significant difference in the detection of proximal caries between clinical diagnosis and radiographic modalities (conventional and digital radiography), however, clinical diagnosis may be further enhanced by using radiographic methods. In the detection of interproximal caries both conventional radiography and direct digital radiography are comparable. Both conventional and digital methods are comparable even for grading or depth or extent of caries.

INTRODUCTION

Dental caries is aptly defined as a progressive, irreversible, microbial disease affecting the hard tissues of the tooth exposed to an oral environment, resulting in demineralization of the inorganic substances and dissolution of the organic constituents, thereby leading to cavity formation.[1]
Dentists commonly use visual, tactile (probing) examination to detect relative changes in dental hard tissues which may not be sufficient for the detection of caries. It is widely accepted that radiography is a vital adjunct for diagnosing caries that detects 30-70% more proximal caries than a clinical examination alone.[2]
Intraoral radiography is relatively easy, inexpensive, and causes minimum radiation exposure.[3,4]
Interproximal caries lesions develop between contacting proximal surfaces of adjacent teeth. The main difficulty in the early diagnosis of these approximal carious lesions arises from their location, usually below the contact areas of two adjacent teeth, impairing direct visual inspection.[5]
Conventional intraoral radiographic examination has its greatest value in the detection of proximal carious lesions that are not easily detectable by careful and thorough clinical examination. The conventional

ISSN (O): 2687-5365; ISSN (P): 2753-6556

intraoral radiograph was found to have limitations, especially in dealing with image processing such as maintenance of processing solutions, x-ray film storage and processing room which required no light exposure.[6]

Digital systems provide facilities for image manipulation e.g. contrast and brightness adjustments, subtraction radiography, as well as reduction in patient dose. Digital radiography also has some limitations which comprise significant cost, uncomfortable rigid and bulky sensors, and depends on operator skill for image acquisition and enhancement.[7]

Hence, the present study was undertaken to compare conventional radiography with digital radiography in the detection of proximal caries.

MATERIALS AND METHODS

The present prospective was conducted amongst 350 subjects of which 158 were males and 192 were females and were selected randomly in the Department of Dentistry, from March 2018 to March 2020 after the approval of the Institutional Ethics Committee. The study included radiographic evaluation of a total of 2100proximal surfaces which included 350 proximal surfaces clinically suspected with caries (as the study group) and 1750 adjacent proximal surfaces (as the control group) which clinically were not suspected as having caries. Further, these 350 proximal carious lesions were evaluated for comparison along with adjacent 1750 proximal surfaces (with clinically not suspected as having caries) on conventional (periapical and bitewing) as well as digital (periapical and bitewing) radiographs.

Inclusion Criteria

Patients clinically suspected of a carious lesion affecting one of the proximal surfaces of a posterior tooth and Subjects with permanent dentition. Exclusion criteria: Subjects with mixed dentition, serious systemic disease, oral lesions making the film placement in the oral cavity difficult, psychological, and mental disorders, noncompliant patients, pregnant women, and patients with grossly malaligned teeth. Details of study subject- Each patient underwent clinical evaluation and the information was entered in the Case History Proforma. Radiographic examination: Each patient was subjected to two Conventional Radiographs, including periapical and bitewing radiograph and two Digital Radiographs, including periapical and bitewing radiographs of the same region in which proximal caries was suspected. The radiographs were taken by using paralleling technique, with the help of plastic film holders with metallic arms, supplied by the manufacturer. During radiation exposure, suitable patient protectors like a lead apron and thyroid collar shield were used. The grading of carious lesion was scored based on a five-point scale given by Russell and Pitts,[8] 0- No radiolucency1- Radiolucency upto outer half of the ename.[12] Radiolucency upto inner half of the ename.[13] Radiolucency upto outer half of dentin4. Radiolucency upto inner half of dentin with or without pulp involvement All the readings (scores and measurements) of Conventional Radiographs and Digital Radiographs were later transferred to a master chart. This data was then subjected to statistical analysis using Chi-square Test, Kappa Statistics, Sensitivity, specificity, PPV, NPV and accuracy using SPSS 17.0.

Color Plate: 1

Figure 1: Intraoral periapical radiograph of maxillary molar region showing mesial proximal caries (Conventional radiographic method)

Figure 2: Bitewing radiograph of maxillary molar region showing mesial proximal caries (Conventional radiographic method)

Color Plate:2

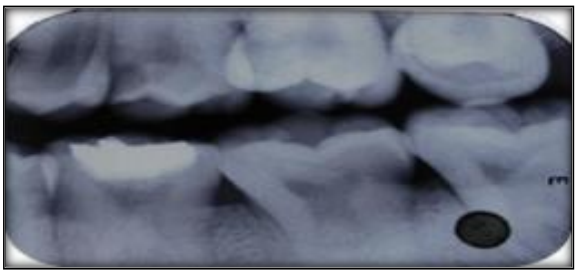


Figure 3: Intraoral periapical radiograph of maxillary molar region showing mesial proximal caries (Direct Digital radiographic method)

ISSN (O): 2687-5365; ISSN (P): 2753-6556

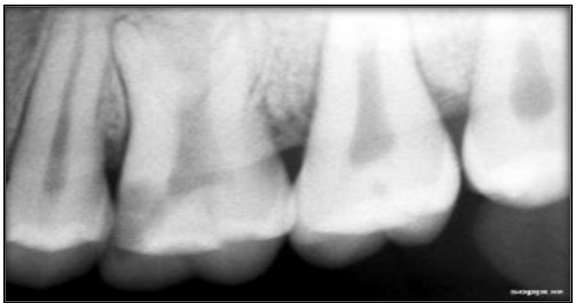


Figure 4: Bitewing radiograph of maxillary molar region showing mesial proximal caries (Direct Digital radiographic method)

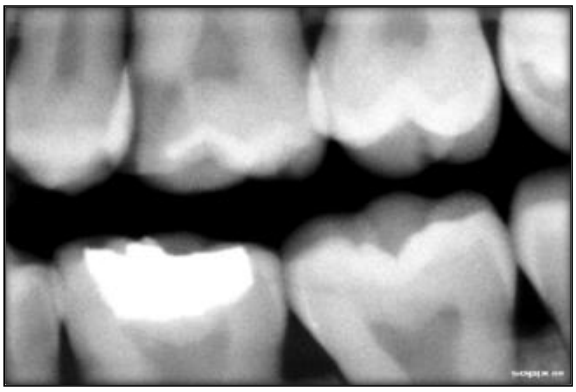


Figure 5:

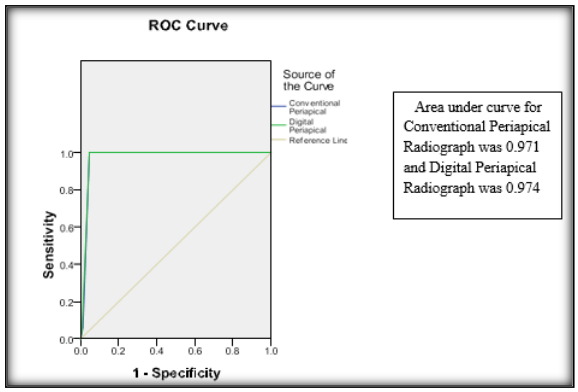
RESULTS

The present study was carried out to compare conventional radiography with direct digital radiography in detection of interproximal caries. The data was then tabulated and presented as graphical representations.

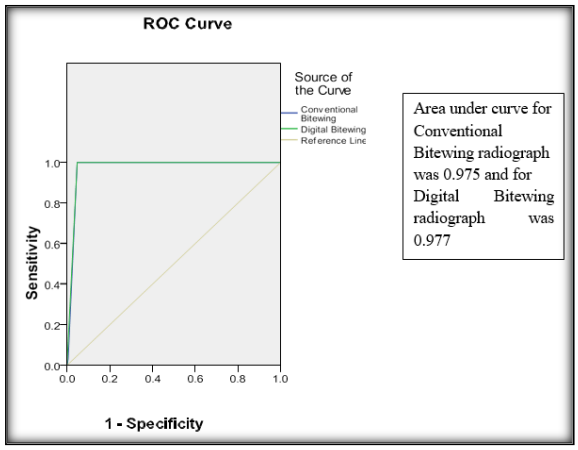
[Table 1] shows the age-wise and gender-wise distribution of subjects. The subjects enrolled were 350 with 350 clinically suspected carious surfaces as the study group and 1750 adjacent surfaces which clinically were not suspected with caries as the control group. Of the 350 subjects, 158(45.14%) were male and 192(54.86%) were female. The mean age of 350 subjects was 36.96±12.28 years.

[Table 2] shows a Comparison of Conventional Periapical Radiographic diagnosis with Digital Periapical Radiographic diagnosis for the detection of proximal caries in 2100 (100%) assessed surfaces (Study group: n=350 (16.66%) surfaces and Control group: n=1750 (83.34%) surfaces). In the Study group, we found that conventional periapical radiographs could detect 329 (15.66%) caries and 21 (1%) were found to be absent with caries. In the Control group, it was found that conventional periapical radiographs could detect 59 (2.8%) caries and 1691 (80.54%) were found to be absent with caries on conventional periapical radiographs. Also, in the study group, 336 (16%) caries were detected and 14(0.66%) did not have caries and in the control group, 68(3.25%) caries were detected and 1682 (80.09%) were absent on digital periapical radiograph.

No statistically significant difference was found between Conventional Periapical Radiographic diagnosis with Digital Periapical Radiographic diagnosis (p=1). Although statistically not significant, the Receiver operating characteristic (ROC) curve showed area under the curve for conventional periapical radiographic diagnosis was 0.971 and digital periapical radiographic diagnosis was 0.974. The ROC curve was slightly higher for digital periapical radiographic diagnosis than for conventional periapical radiographic diagnosis. So, the diagnostic accuracy for digital periapical radiographic diagnosis was more than for conventional periapical radiographic diagnosis. ROC curves for both almost overlapped each other and both modalities were comparable.



Graph 1: ROC curve for Comparison of Conventional Periapical radiographic diagnosis and Digital Periapical radiographic diagnosis for Presence or Absence of proximal carious lesion in Study group and Control group (n=2100 surfaces)



Graph 2: ROC curve for Comparison of Conventional Bitewing radiographic diagnosis and Digital Bitewing radiographic diagnosis for Present or Absence of proximal carious lesion Study group and Control group (n=2100 surfaces)

[Table 3] shows Comparison of Conventional Bitewing radiographic diagnosis with Digital Bitewing radiographic diagnosis for detection of proximal caries in 2100 (100%) assessed surfaces (Study group: n=350 (16.66%) surfaces and Control group: n=1750 (83.34%) surfaces). In the Study

ISSN (O): 2687-5365; ISSN (P): 2753-6556

group, 339(16.14%) proximal surface caries were present and 11 (0.52%) were absent. In the Control group, 74(3.54%) proximal surface caries were present and 1676 (79.80%) were absent with caries on conventional bitewing radiographs. Also, in the study group, 342(16.28%) proximal surface caries were present and 8(0.38%) were absent with caries. In the control group, 82(3.92%) proximal surface caries were present and 1668(79.42%) were absent with caries on digital bitewing radiograph. p-value for this observation is not statistically significant (p=1). Although it is so, the Receiver operating characteristic (ROC) curve showed area under the curve for conventional bitewing radiograph was 0.975 and for digital bitewing radiograph was 0.977. The ROC curve was slightly higher for digital bitewing radiographic diagnosis than for conventional bitewing radiographic diagnosis. So, the diagnostic accuracy for digital bitewing radiographic diagnosis was marginally more than conventional bitewing radiographic diagnosis. ROC curves almost overlapped each other and both modalities were comparable.

[Table 4], shows a Comparison of grading of caries on Conventional periapical and digital periapical radiographs in 2100 (100%) surfaces (Study group: n=350 (16.66%) surfaces clinically suspected to have proximal caries and Control group: n=1750 (83.34%) surfaces clinically not suspected to have proximal caries). Grading of caries on conventional periapical radiographs and digital periapical radiographs for determination of the absence of caries (grade 0), the extent of caries in enamel (grade 1 and grade 2) and dentin (grade 3 and 4) were compared.

In the Study group, 20 (0.95%) were found to be of grade 0, 141(6.71%) proximal carious lesions on conventional periapical radiographs were present in enamel while 189 (9%) were present in dentin. In the Control group, 1691 (80.52%) were found to be absent (grade 0), 59(2.82%) were present in enamel (grade 1 and 2) while 0 (0%) were present in dentin (grade 3 and 4) on conventional periapical radiograph.

Also, in the Study group, 16 (0.77%) were to be of grade 0, 119 (5.66%) were present in enamel (grades 1 and 2) while 215 (10.23%) were present in Dentin (grades 3 and 4). In the control group, 1682 (80.09%) were found to be of grade 0, 68 (3.25%) were present in enamel (grades 1 and 2) while 0 (0%) were present in dentin (grade 3 and 4) on digital periapical radiographs.

There was no statistically significant difference found between conventional periapical radiographic diagnosis and digital periapical radiographic diagnosis (p=0.99).

[Table 5], shows Comparison of grading of Conventional bitewing and Digital bitewing radiograph in 2100 (100%) surfaces (Study group: n=350 (16.66%) surfaces clinically suspected to have proximal caries and Control group: n=1750 (83.34%) surfaces clinically not suspected to have proximal caries). Grading of caries on conventional bitewing radiographs and digital bitewing radiographs for determination of the absence of caries (grade 0), the extent of caries in enamel (grade 1 and grade 2) and dentin (grade 3 and 4) were compared.

In the Study group, 11(0.52%) were found to be absent (grade 0). 125(5.95%) proximal carious lesions were present in enamel (grade 1 and 2) while 214 (10.19%) were present in dentin (grade 3 and 4). In the Control group, 1681 (80.06%) proximal caries were absent (grade 0), 69(3.28%) involved enamel (grade 1 and 2) and 0 (0%) involved dentin (grade 3 and 4) on conventional bitewing radiographs.

Also, in the Study group, the percentage of proximal carious lesions which were absent (grade 0) was 8 (0.38%), 103(4.90%) were present in enamel (grade 1 and 2) while 239 (11.38%) were present in dentin (grade 3 and 4). In the Control group, 1668 (79.42%) proximal carious lesions were absent (grade 0), 82 (3.92%) were involved in enamel (grade 1 and 2) and 0 (0%) were involving dentin (grade 3 and 4) on digital bitewing radiograph.

There was no significant difference found between conventional bitewing and digital bitewing radiographs (p=0.99).

Table 1: Demographic Characteristics of 350 subjects evaluated for the study

Groups	Study Group (n=350 surfaces, clinically suspected for proximal caries)	Control Group (n=1750 adjacent surfaces, clinically not suspected for proximal caries)	p-value
Mean Age (Yrs)	36.96±12.28	36.96±12.28	0.87 NS, p>0.05
Gender (%)			
Male	158(45.14%)	158(45.14%)	0.25, NS, p>0.05
Female	192(54.86%)	192(54.86%)	

Table 2: Comparison of Conventional Periapical Radiographic diagnosis with Digital Periapical Radiographic diagnosis for detection of proximal caries in Study group (n=350) and Control group (n=1750)

Diagnostic method	Study Group			Control Group			Total	χ^2-value	p-value
	Caries Present	Caries Absent	Total	Caries Present	Caries Absent	Total			
Conventional Periapical radiograph	329 (15.66%)	21(1%)	350 (16.66%)	59 (2.8%)	1691 (80.54%)	1750 (83.34%)	2100 (100%)	0.000	1.00 NSp> 0.05
Digital Periapical radiograph	336 (16%)	14 (0.66%)	350 (16.66%)	68 (3.25%)	1682 (80.09%)	1750 (83.34%)	2100 (100%)		

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 3: Comparison of Conventional Bitewing radiographic diagnosis with Digital Bitewing radiographic diagnosis for detection of proximal caries in Study group (n=350) and Control group (n=1750)

Diagnostic method	Study Group			Control Group			Total	χ2-value	p-value
	Caries Present	Caries Absent	Total	Caries Present	Caries Absent	Total			
Convention al Bitewing radiograph	339 (16.14%)	11 (0.52%)	350 (16.66%)	74 (3.54%)	1676 (79.80%)	1750 (83.34%)	2100 (100%)	0.0	1.00 NS,
Digital Bitewing radiograph	342 (16.28%)	8 (0.38%)	350 (16.66%)	82 (3.92%)	1668 (79.42%)	1750 (83.34%)	2100 (100%)	00	p>0.05

Table 4: Comparison of grading of caries on Conventional Periapical and Digital Periapical radiograph in Study group (n=350) and Control group (n=1750)

Diagnostic method	Study group				Control group				Total	χ2value	p-value
	Zero (Grade 0)	Enamel (Grade 1+2)	Dentin (Grade 3+4)	Total	Zero (Grade 0)	Enamel (Grade 1+2)	Dentin (Grade 3+4)	Total			
Conventional Periapical radiograph	20 (0.95%)	141 (6.71%)	189 (9%)	350 (16.66%)	1691 (80.52%)	59 (2.82%)	0 (0%)	1750 (83.34%)	2100 (100%)	0.13	0.99 NS p>0.05
Digital Periapical radiograph	16 (0.77%)	119 (5.66%)	215 (10.23%)	350 (16.66%)	1682 (80.09%)	68 (3.25%)	0(0%)	1750 (83.34%)	2100 (100%)		

Table 5: Comparison of grading of caries on Conventional Bitewing and Digital Bitewing radiograph in Study group (n=350) and Control group (n=1750)

Diagnostic method	Study group				Control group				Total	χ2-value	p-value
	Zero (Grade 0)	Enamel (Grade 1+2)	Dentin (Grade 3+4)	Total	Zero (Grade 0)	Enamel (Grade 1+2)	Dentin (Grade 3+4)	Total			
Conventional Bitewing radiograph	11 (0.52%)	125 (5.95%)	214 (10.19%)	350 (16.66%)	1681 (80.06%)	69 (3.28%)	0(0%)	1750 (83.34%)	2100 100%)	0.28	0.99 NS, p> 0.05
Digital Bitewing radiograph	8 (0.38%)	103 (4.90%)	239 (11.38%)	350 (16.66%)	1668 (79.42%)	82 (3.92%)	0(0%)	1750 (83.34%)	2100 (100%)		

DISCUSSION

Dental caries is aptly defined as a progressive, irreversible, microbial disease affecting the hard tissues of the tooth exposed to an oral environment, resulting in demineralization of the inorganic substances and dissolution of the organic constituents, thereby leading to cavity formation.[1] Conventional intraoral radiographic examination has its greatest value in the detection of proximal carious lesions that are not easily detectable by careful and thorough clinical examination. The conventional intraoral radiograph was found to have limitations, especially in dealing with image processing such as maintenance of processing solutions, x-ray film storage and processing room which required no light exposure.[6] Digital systems provide facilities for image manipulation e.g. contrast and brightness adjustments, subtraction radiography, as well as reduction in patient dose. We enrolled 350 patients who had 350 clinically suspected carious surfaces as the study group and 1750 adjacent surfaces which clinically were not suspected with caries as the control group. Of the 350subjects, 158(45.14%) were male and 192(54.86%) were female. The mean age was 36.96±12.28 years. Radiographs were taken with standard exposure parameters and conventional radiographs were developed using the automatic processor. Further, these were evaluated for comparison of conventional (periapical and bitewing) as well as digital (periapical and bitewing) radiographs on the same radiographic film and image respectively for detection of carious lesions along with grading or depth of extent of caries. Intra-observer agreement calculated by kappa statistics for detection of proximal caries on conventional periapical, conventional bitewing, digital periapical, and digital bitewing radiographs in the study group ranging from 0.68 to 0.75 which was suggestive of good agreement. In our study, the Receiver operating characteristic (ROC) curve showed area under the curve for conventional bitewing radiograph was 0.975 and for digital bitewing radiograph was 0.977. (table 3) The ROC curve was slightly higher for digital bitewing radiographic diagnosis than for conventional bitewing radiographic diagnosis. So, the diagnostic accuracy for digital bitewing radiographic diagnosis was marginally more than conventional bitewing radiographic diagnosis. ROC curves almost overlapped each other and both modalities were comparable. Results of similar nature were found by Senel B et al,[9] also performed an in vitro study on assessing the diagnostic ability of film (periapical) and CCD (periapical), visual examination, PSP and CBCT for detection of proximal caries on 138 teeth (276 surfaces) and found no statistically significant difference in between different modalities (p>0.05) and they concluded that these modalities performed similarly in the detection

ISSN (O): 2687-5365; ISSN (P): 2753-6556

of proximal caries which agreed with our study. Naitoh M, Yuasa H, Toyama M et al,[10] performed a study in which observers assessed the presence or absence of proximal caries using direct digital radiography and film. They found that kappa scores were 0.767 for digital systems and 0.781 for film-based bitewing suggesting that intraobserver agreement showed substantial to almost perfect agreements which was by our study. Ali Abid Al-Rhida J et al,[11] compared the diagnostic accuracy of Ekta speed plus film (bitewing) and digital (bitewing) radiography in an in vitro study on 20 extracted posterior teeth and divided them into sound teeth group and carious teeth group. High score values were given to Ekta-speed plus films. It was thought to be because of the high degree of sharpness and resolution of the conventional radiographs and was superior over the computer images in the evaluation of proximal caries in posterior teeth and there was a highly significant difference found between film and digital images (p=0.000). Their result was in contrast to the results of the present study. Castro V et al,[7] performed an in vitro study for comparison of the conventional film (periapical) and direct digital imaging(periapical) for evaluating the depth of approximal caries and found no statistically significant difference in the detection of proximal caries(p=0.226). The area under the curve for caries involving enamel by the film was 0.6565, by digital was 0.6167 and inversion was 0.6287 and the area under the curve for dentin by the film was 0.8863, digital was 0.8482, and inversion was 0.8527. The authors concluded that the overall diagnostic accuracy of the three modalities tested was comparable in the detection of approximal caries which was by our study. The area under the curve was more for film for caries involving enamel as well as dentin compared to digital images. This suggests that film was more diagnostically accurate as compared to digital images. This was in contrast to the results of our study. Moystad A et al,[12] area conducted an in vitro study on the comparison of enhanced, and unenhanced storage phosphor images and dental X-ray films using the periapical radiographic method. They found enhanced images had significantly higher area under curve (Az) values (0.819 for enamel and 0.845 for dentin) than film (0.688 for enamel and 0.793 for dentin). They concluded that enhanced SP images were better than film in both enamel and dentin which was by our study. Syriopoulos K et al,[13] in an invitro study, radiographed 56 extracted teeth using two E-speed dental films, two CCD systems and two Storage phosphor digital images using bitewing radiography. They found no significant difference in diagnostic accuracy with dental films and digital systems (p>0.05). The depth of the lesion did not seem to affect the performance of the system examined. The diagnostic accuracy of digital systems was comparable with that of dental films which was by the present study. Versteeg K et al,[14] performed an in vivo study to compare approximal caries depth on storage phosphor plate images to conventional film using bitewing radiography. They concluded that the caries depth on storage phosphor plate images was underestimated compared with the film-based images which contrasted with other in vitro studies. The possible explanation mentioned by them was different conditions of an in vivo study such as the presence of soft tissue. The results of this study were in contrast to our study as well. In our study, as shown in Tables 4 and 5 there was no significant difference in grading or depth of extent of caries on conventional periapical and digital periapical radiographs. Also, no significant difference in grading or depth extent of caries on conventional bitewing and digital bitewing radiograph Torman Alkurt M et al,[15] compared four different dental X-ray films and direct digital radiography in an invitro study using bitewing radiography for proximal caries detection. They found the area under the curve (Az) values were 0.843,0.811, 0.800, 0.796, and 0.793 for Ekta speed plus, agfa dentus m2 comfort, Insight, Flow Xray and RVG respectively and found no statistically significant difference between these modalities which agreed with our study. However, the area under the curve was the least for RVG compared to four different X-ray films which suggests that diagnostic accuracy for films was slightly higher as compared to RVG which was in contrast to the results of our study. Intraobserver agreement calculated by kappa statistics for Grading or depth of extent of caries on Conventional Periapical radiographic method, Conventional Bitewing radiographic method, Digital Periapical radiographic method, Digital Bitewing radiographic method ranging from 0.82 to 1.00 which was suggestive of very good agreement in study and control group.

CONCLUSION

We conclude from the present study that although there was no statistically significant difference in the detection of proximal caries between clinical diagnosis and radiographic modalities (conventional and digital radiography), clinical diagnosis may be further enhanced by using radiographic methods. In the detection of interproximal caries both conventional radiography and direct digital radiography are comparable. Both conventional and digital methods are comparable even for grading or depth or extent of caries.

REFERENCES

1. Peter S. Essentials of Preventive and Community Dentistry. Second edition. Arya publishing house. 2003; 241.
2. White S, Atchison K, Hewlett E and Flack V. Efficacy of F.D.A guidelines for ordering radiographs for caries detection. Oral Surg Oral Med Oral Pathol. 1994; 77:531-540
3. White S., Pharoah M. Oral Radiology. Principles and interpretation-6th Ed-Mosby- An imprint of Elsevier.2009;280.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

4. Braga M, Mendes F, Ekstrand K. Detection Activity Assessment and Diagnosis of Dental Caries Lesions. Dent Clin N Am. 2010;479-493.
5. Belém M, Tabchoury C, Ferreira-Santos R, Groppo F and Haiter-Neto F. Performance of a photostimulable storage phosphor digital system with or without the sharpen filter and cone heam CT for detecting approximal enamel surface demineralization. Dentomaxillofacial Radiology.2013;(42):1-9.
6. Wei O, Rahman S, Shaari R, Mon Mon Tin O, Alam M. Comparison of Image Clarity between Digital and Conventional Radiography International Medical Journal. 20(3); 2013:329-331.
7. Castro V, Katz J, Hardman P, Glaros A, Spencer P. In vitro comparison of conventional film and direct digital imaging in detection of approximal caries. Dentomaxillofac. Radiol. 2007; 36:138-142.
8. Russel M, Pitts B. Radiovisiographic diagnosis of dental caries. Initial comparison of basic mode video prints with bitewing radiography. Caries Res. 1993; 27:65-70.
9. Senel B, Kamburoglu K, Ucok O, Yuksel S, Ozen T and Avsever H. Diagnostic accuracy of different imaging modalities in detection of proximal caries. Dentomaxillofac. Radiol. 2010; 39:501–511.
10. Naitoh M, Yuasa H, Toyama M, Shiojima M, Nakamura M, Ushida M, et al. Observer agreement in detection of proximal caries with direct digital intraoral radiography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998; 85:107-112.
11. Ali Abid Al-Rhida J, Salah Al-Deen Al-Qizweeny R, Ahmed Fattah A. Value of digital radiography in evaluating proximal caries in comparison with conventional radiography (Comparative study). J Bagh Coll Dentistry.2007;19(1):55-57.
12. Moystad A, Svanaes D, Risnes S, Larheim T and Grondahl H. Detection of approximal caries with storage phosphor system. A comparison of enhanced digital images with dental X-ray film. Dentomaxillofac. Radiol. 1996; 25:202-206.
13. Syriopoulos K, Sanderink G, Velders X, van der Stelt P. Radiographic detection of approximal caries: a comparison of dental films and digital imaging systems. Dentomaxillofac. Radiol.2000;29:312-318.
14. Vertseeg K, Sanderink G, Velders X, van Ginkel F, van der Stelt P. In vivo study of approximal caries depth on storage phosphor plate images compared with dental x-ray film.Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997; 84:210-213.
15. Torman Alkurt M, Peker I, Bala O, Altunkaynak B. In Vitro Comparison of Four Different Dental X-ray Films and Direct Digital Radiography for Proximal Caries Detection, Operative Dentistry. 2007; 32(5): 504-509.

ISSN (O): 2687-5365; ISSN (P): 2753-6556