Original Article

Evaluation of Diagnostic Efficacy of Improved Interproximal Program and Bitewing Program in Proximal Caries Detection- An Extraoral Radiographic Comparative Study

Bilahari Naduvakattu, Laxmikanth Chatra[1], Prasanth Shenai K[1], Ashir K R[2], Suresh Kandagal Veerabhadrappa[3], Devika Shetty[4]

Department of Oral Medicine and Radiology, St. Gregorios Dental College, Chelad, Kerala, [1]Department of Oral Medicine and Radiology, Yenepoya Dental College, Deralakatte, Karnataka, [2]Department of Oral Medicine and Radiology, KMCT Dental College, Kozhikode, Kerala, India, [3]Department of Oral Diagnostic Sciences, Faculty of Dentistry, SEGI University, Malaysia, [4]Oral Stomatologist and Maxillofacial Radiologist, 'Elite dentistry', Milestone 25, Balmatta, Mangalore, Karnataka, India

Abstract

Background: To look for an alternative to intraoral bitewing radiographs when the intraoral placement of film is not feasible or multiple teeth have to be screened. **Objectives:** A study to evaluate and compare the efficacy of improved interproximal and bitewing programs for detection of proximal caries Planmeca ProMax was conducted. **Materials and Methods:** Fifty patients who were screened for proximal caries and confirmed with intraoral bitewing radiography were subjected to improved interproximal program and bitewing program in Planmeca ProMax (Planmeca Oy, Helsinki, Finland) after obtaining informed consent. These radiographs were evaluated by three observers. Intra- and interclass correlation was done to check reliability of the observers, and ROC analysis was done to evaluate the diagnostic accuracy. Critical ratio analysis was done to know the significance. **Results:** Both improved interproximal program and bitewing programs have similar diagnostic efficacy. ROC curve area of improved interproximal program was 0.833 while bitewing program showed 0.878. Bitewing program showed specificity value of 76% compared to 67% in improved interproximal program while both were equally sensitive. **Conclusion:** Both bitewing program and improved interproximal program are highly sensitive in detecting proximal caries when compared to intraoral bitewing radiography which is still considered the gold standard in diagnosis of an interproximal caries.

Keywords: Bitewing program, improved interproximal program, orthopantomograph, planmeca ProMax

INTRODUCTION

Since the density of the proximal surface is large and mineralization is less, it is quite difficult to identify an interproximal caries occurring in the early stages.[1] The conventional intra-oral bitewing technique is still considered ideal in proximal caries and alveolar bone loss detection due to its projection geometry and better image resolution. Panoramic radiography can be opted to reduce patient discomfort and radiation dose if multiple teeth have to be radiographed compared to intraoral. Panoramic radiography alone is considered inferior to bitewing radiography in the diagnosis of proximal caries due to its lesser resolution of structures, unequal magnification, and geometric distortion and proximal overlap.[2,3] The newer panoramic machines incorporate programs like improved interproximal and bitewing programs that open the contact points of the premolars so that interproximal carious lesions are visible on a panoramic image. Planmeca machine uses SCARA technology which provides interproximal separation between contacts.[4]

This study evaluated and compared the efficacy of improved interproximal program and bitewing program in the detection of proximal caries keeping intraoral bitewing as gold standard.

Address for correspondence: Dr. Bilahari Naduvakattu, Professor and Head, Department of Oral Medicine and Radiology, St. Gregorios Dental College, Chelad PO, Kothamangalam, Ernakulam, Kerala, India. E-mail: nbilaharin@gmail.com

Access this article online

Quick Response Code:

Website: www.jiaomr.in

DOI: 10.4103/jiaomr.jiaomr_215_22

Material and Methods

Fifty individuals from 18 to 60 years with clinically diagnosed incipient proximal caries of premolars and molars were included in this study. Large carious lesions and proximal caries adjacent to edentulous areas were excluded. Informed consent was obtained from all the patients who were willing to participate in the study. Study was conducted in a span of 2 years. Sample size was calculated using the formula $n = z^2 \times p\,(1-p)/\epsilon^2$ where n is the sample size, z the z-score, p the population proportion, and ϵ denotes margin of error. Considering a confidence level 95% and margin of error of 0.5% with population proportion of 0.42, at least 648 surfaces would be required. A total of 651 surfaces were assessed. Ethical approval was obtained to conduct this study from Yenepoya University Ethical Committee.

All the clinically diagnosed incipient proximal caries were confirmed with conventional intraoral bitewing radiography using IOPA machine (Satelec Image X, Italy). The X-ray unit operated at 70 kVp and 8 mA, and the exposure time was fixed at 0.5 sec. Bitewing radiographs were taken with bitewing XCP. The films used were No. 2 Kodak intraoral E-speed films. Patients were made to wear a lead apron and a thyroid shield during exposure. The radiographs were processed in Velopex XE automatic processor. These individuals were subjected to panoramic radiography using improved interproximal program and bitewing program in Planmeca ProMax (Planmeca Oy, Helsinki, Finland) panoramic X-ray machine. The films used were Kodak T-Mat G panoramic films. In all the cases, mAs were kept as 10 and kVp at 70. Exposure time was automatically set at 16 seconds for the improved interproximal program and 11 seconds for bitewing program. Safety procedure of wearing lead apron was taken care in all the patients. The films were processed in Velopex XE automatic processing machine.

Two panoramic modes thus obtained; improved interproximal program [Figure 1] and bitewing program [Figure 2] were coded and given to three observers for evaluation. To avoid bias, the panoramic radiographs were given separate days for evaluatio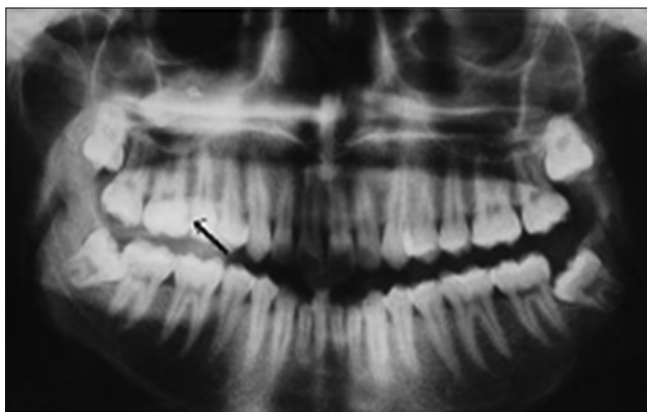n. Each observer was given an orientation session to make them familiarize with the two programs. Observers were asked to examine the presence of proximal caries and to rate their level of confidence with the following five-point scale in a scoring chart which is given below. 1 = Caries definitely absent, 2 = Caries probably absent, 3 = Equal chance of caries being present or absent, 4 = Caries probably present, and 5 = Caries definitely present. All the examiners were provided with an X-ray viewer, and standardized viewing conditions were followed for all three observers. The lengths of the sessions were entirely at the discretion of viewers.

Statistical analysis

The receiver operating characteristic (ROC) using SPSS and asymptotic 95% confidence intervals were used to find the diagnostic accuracy of both programs. Critical ratio analysis was done to find the significance of both the programs. Intraclass correlation was done to find the interobserver reliability in each program and intrarater reliability of the observers. *P* value for both programs was assessed.

Results

A total of 588 sound surfaces and 63 carious surfaces were detected according to the true disease status, determined by intraoral bitewing radiography. The interobserver reliability, according to intraclass correlation, was in the range of 0.899 for bitewing program and 0.954 for improved interproximal program, for which a score above 0.8 is considered to be highly reliable [Table 1]. Thus, reliability between the observer values was very high in both programs. The intrarater reliability was also calculated, i.e., each observer values among the two programs were calculated. This was found to be 0.640–0.772 and 0.719, respectively, for three observers, which was also considered to be fairly reliable [Table 2]. Mean values of the three observers were calculated for improved interproximal

Table 1: Inter-rater reliability between three observers

	Intraclass correlation ((ICC)
Bitewing program	0.899
Improved interproximal program	0.954

An ICC >0.8 shows agreement scale is highly reliable

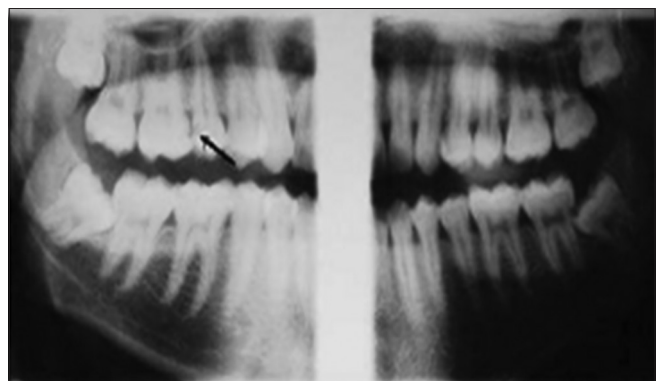**Figure 1:** Panoramic radiograph in improved interproximal program

Figure 2: Panoramic radiograph in bitewing program

with bitewing program, intraoral bitewing with improved interproximal program, and intraoral bitewing with bitewing program. Critical ratio analysis of the maximum likelihood areas was calculated from the observer values. *P* values of both programs compared with intraoral bitewing radiography were < 0.0005, which was highly significant. No significant difference was seen between two panoramic programs in overall performance in the detection of proximal carious lesions. Hence, it was inferred that based on mean value of the observers, both programs are almost equal to the gold standard used. Significant differences in values were not found in between the two programs [Table 3]. The overall diagnostic accuracies of the two programs compared with intraoral bitewing were done using ROC curve analysis and 95% asymptotic confidence interval. The improved interproximal program, when compared with intraoral bitewing, was in the ROC curve area range of 0.833 [Table 4]. *P* value was 0.007 in improved interproximal which was highly significant [Table 5]. The bitewing program, when compared with intraoral bitewing, was in the ROC curve area range of 0.878 [Table 4]. *P* value was 0.002 in bitewing program which also indicated high significance [Table 5]. When comparison was made between two programs, probability value was significant, which was less than 0.005 [Table 5]. The ROC curves generated indicate the overall diagnostic accuracy of the two panoramic programs. High significance was found in both programs [Graphs 1 and 2]. 100% significance was seen in both programs. Specificity was 67% in improved interproximal program and 76% in bitewing program. Curve within the area of 1.0 represents perfect precision accuracy, whereas diagonal line within an area of 0.5 represents random decision accuracy that is equivalent to guessing.

DISCUSSION

Interproximal caries is difficult to be detected clinically, and intraoral bitewings are the ideal in detecting interproximal caries. Akkaya N (2006)[5] proposed that the image resolution of panoramic radiography has increased with technological improvements and becomes comparable with intraoral radiography for the diagnosis of dental caries. Improved interproximal and bitewing program reduces the proximal overlap by keeping the X-ray beam and interproximal contacts of the teeth parallel. Bitewing program uses the same projection geometry and gives a bitewing like magnified image.[6]

Inter-rater reliability of 0.954 and 0.899 was noted for both programs, and intrarater reliability was 0.640, 0.772, and 0.719, respectively, for the first, second, and the third observers which was consistent with Akarslan ZZ (2008)[7] study who also found an almost complete observer reliability while using three observers.

Critical ratio analysis was performed for all possible pairings of modalities used to determine statistical significance. Mean value of the observers was considered for this test. Both programs showed a probability value less than 0.005 which was highly significant. However, no significant difference

Graph 1: ROC curve—improved interproximal program vs. intraoral bitewing radiography

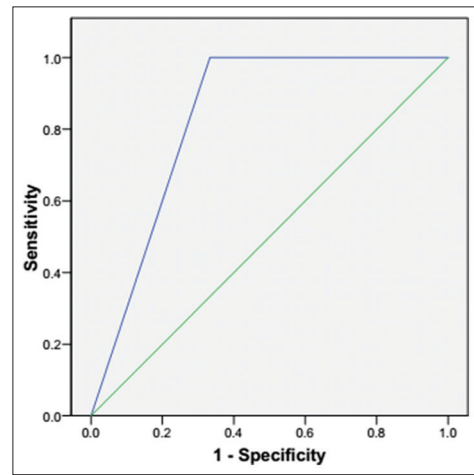| Table 2: Intrarater reliability-inter proximal program vs. bitewing program	
	Intraclass correlation (ICC)
Observer 1	0.640
Observer 2	0.772
Observer 3	0.719
An ICC >0.6 shows agreement scale is fairly reliable	

Table 3: Comparisons of mean scores					
	Mean	**Std. Deviation**	**Critical ratio**	**P**	**Significance**
Pair 1					
Improved interproximal program	3.0467	1.83690	-0.670	0.506	NS
Bitewing program	3.2000	1.72089			
Pair 2					
Intraoral bitewing	4.40	1.262	6.035	<0.0005	S
Radiography	3.0467	1.83690			
Improved interproximal program					
Pair 3					
Intraoral bitewing	4.40	1.262	5.793	<0.0005	S
Radiography	3.2000	1.72089			
Bitewing program					

was seen between two panoramic programs. Scarfe *et al.* [1994][8] obtained significant values on comparing bitewing with standard panoramic and orthogonal projections and a non-significant probability value when compared standard with orthogonal projections.

Improved interproximal program, when compared with intraoral bitewing, was in the ROC curve area range of 0.833. As the area under the curve reaches 1.0, it was considered to be perfect diagnostic accuracy. Hence, the overall diagnostic accuracy of this program was high. Scarfe *et al.* [1994][8] who compared standard and panoramic projections obtained low accuracy. Earlier programs had a disadvantage of proximal overlapping, especially on premolars which reduce the identification of caries on interproximal areas. Goodarzi *et al.* [2010][9] compared the overlapping of posterior teeth using two techniques of improved interproximal panoramic program and standard panoramic and found that improved interproximal panoramic program significantly reduced the overlapping of proximal surfaces in the panoramic radiographs of posterior teeth as compared to the standard panoramic technique. This substantiates the higher diagnostic accuracy while using improved interproximal panoramic program.

A 100% sensitivity and a 67% specificity were obtained on using improved inter proximal panoramic program. All the actual carious lesions were detected by this program, even though absence of the caries was detected only to a 67%.

Bitewing program, when compared with intraoral bitewing AUC in the ROC, was in range of 0.878. As the AUC reaches 1.0, it was considered to be perfect [Table 6]. Hence, the overall diagnostic accuracy of this program was high. Goodarzi *et al.* [2010][9] found that improved interproximal panoramic program significantly reduced the overlapping of proximal surfaces in the panoramic radiographs of posterior teeth.

A 100% sensitivity and a 76% specificity were obtained on using bitewing program. All the actual carious lesions were detected by this program, and an absence of the caries was detected to 76%. Hence, a slightly higher diagnostic accuracy

Graph 2: ROC curve—bitewing program vs. intraoral bitewing radiography

can be said in case of this program. [Table 7]. When improved interproximal program was pitted against bitewing program, sensitivity was 81% and specificity was 79% [Table 8].

White SC [1992][10] stated that the effective dose of panoramic radiography was less than 10% of full mouth survey made with D-speed film and round collimation. Manufacturers claim a 50% dose reduction in bitewing program compared to other panoramic programs. This adds the credibility of this program to be included in the routine dental survey as it is diagnostically comparable to intraoral bitewing radiography with a reduction in dose.[4]

ROC analysis was used in our study as it provides the most meaningful approach to compare the diagnostic performance of two or more different radiographic imaging modalities. It distinguishes between the inherent capacities of the observers to under- and over-read when interpreting imaging. The analysis is made by comparing significant differences between the areas under the ROC curves that represent the competing modalities.[5,11]

Table 4: Area under the curve. Test result variable (s): improved interproximal program

Area	Std. Error	Asymptotic 95% CI	
0.833	0.063	0.711	0.956

Table 5: Improved interproximal program vs. intraoral bitewing radiography cross-tabulation

	Intraoral bitewing radiography		Total
	≤1.5 positive	>1.5 negative	
Improved interproximal program			20
≤1.5 positive	5	15	30
>1.5 negative	0	30	
Total	5	45	50

P=0.007 sig. Sensitivity=100%, Specificity=67%

Table 6: Area under the curve. Test result variable(s): bitewing program

Area	Std. Error	Asymptotic 95% CI	
0.878	0.051	0.777	0.978

Table 7: Bitewing program versus intraoral bitewing radiography cross-tabulation

	Intraoral bitewing radiography		Total
	≤1.5 positive	>1.5 negative	
Improved bitewing program			
<=1.5 positive	5	11	16
>1.5 negative	0	34	34
Total	5	45	50

P=0.002 sig. Sensitivity=100%, Specificity=76%
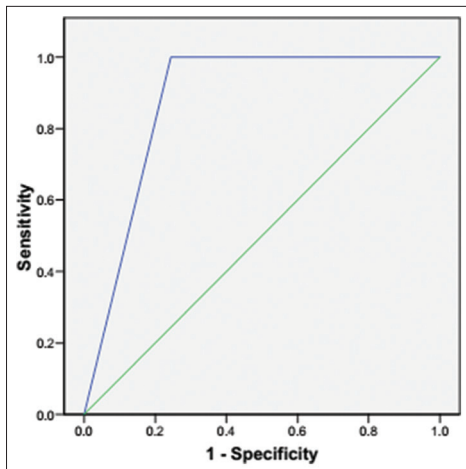
Table 8: Improved interproximal program vs. bitewing program cross-tabulation

	Bitewing program		Total
	≤1.5 positive	>1.5 negative	
Improved interproximal program			
<=1.5 positive	13	7	20
	65%	35%	
	81%	20.9%	
>1.5 negative	3	27	30
	10%	90%	
	18.8%	79.4%	
Total	16	34	50

P<0.0005 sig. Sensitivity=81%, Specificity=79%

The clinical evaluation of diagnostic systems with ROC analysis requires the true status of the disease. The absolute truth would be obtained by extraction and histologic sectioning of teeth, which is impossible to determine in this study. Douglass CW[12] and Valachovic RW[13] have proposed a number of means to determine relative diagnostic truth in clinical dental caries studies including the use of clinical or radiographic consensus. Scarfe[8] supported that in situations where "true gold standard" is unobtainable, the best available estimate may be used as a substitute.

Kamburoglu K[1] in 2012 had used 80 extracted teeth in comparing proximal caries detection using intraoral bitewing, extraoral bitewing, and panoramic radiography where histological sectioning was possible that determined the true status of the disease. However, in cases where the actual status of the examined tooth surface cannot be determined, as in our *in vivo* study, the consensus radiographic standard of the observers participating in the study could be used as the gold standard.[5,14] Akkaya in 2006 also used the consensus radiographic standard obtained with the same observers who evaluated the sessions, and treated the values with receiver operating characteristic (ROC) analysis, and the term diagnostic accuracy was mentioned.[5,15]

Studies have found the accuracy of interproximal caries detection using digital and film radiography to be similar.[16] The digital enhancements of the digitized radiographic images were also compared in some studies, but there were no statistically significant improvements in the detection of interproximal caries parameters. We have used films for both extraoral techniques.

Although intraoral bitewing radiography is still the best method of choice for proximal caries diagnosis, if it is impossible to obtain intraoral bitewing images, then extraoral bitewing radiographic techniques like improved interproximal program and bitewing program can be used in detecting proximal caries in patients who have a gag reflex, who have limited mouth opening due to trismus or any orofacial infection, and who are physically disabled or mentally retarded.[4,17]

CONCLUSION

It was concluded from our study that both interproximal and bite wing programs have got high sensitivity in detecting proximal caries, comparable with intraoral bitewings. In addition, they are suitable in patients with trismus, disability, claustrophobia, or severe gag reflex. Bitewing program provides 50% dose reduction compared with the normal panoramic program making this an option in proximal caries detection.

Limitations

This was done in a film-based system to reduce the enhancement factor in digital modes. Observer skills and experience may have affected the outcome. Future prospects:

Digital extraoral programs can be opted where mass screening has to be done or where intraoral bitewings are not feasible, provided the cost factor can be adjusted.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Key message

Extraoral programs were as comparable as intraoral bitewing in proximal caries detection.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Kamburoglu K, Kolsuz E, Murat S, Yuksel S, Ozen T. Proximal caries detection accuracy using intraoral bitewing radiography, extraoral bitewing radiography and panoramic radiography. Dentomaxillofac Radiol 2012;41:450–9.
2. Williams FJ, Hudson FR, Markus AF. Rotational panoramic radiography: A comparison of radiation doses in the standard and reverse positions. Br J Radiol 1986;59:1219-23.
3. Haring JI, Jansen L. Radiation history. Ch 1. In: Dental Radiography- Principles and Techniques. 2nd ed. New Delhi: Saunders; 2000. p. 3-11.
4. Abu El-Ela WH, Farid MM, Mostafa MS. Intraoral versus extraoral bitewing radiography in detection of enamel proximal caries: An ex vivo study. Dentomaxillofac Radiol 2016;45:20150326.
5. Akkaya N, Kansu O, Kansu H, Cagirankaya LB, Arslan U. Comparing the accuracy of panoramic and intraoral radiography in the diagnosis of proximal caries. Dentomaxillofac Radiol 2006;35:170-4.
6. Abdinian M, Razavi SM, Faghihian R, Samety AA, Faghihian E. Accuracy of digital bitewing radiography versus different views of digital panoramic radiography for detection of proximal caries. J Dent (Tehran) 2015;12:290-7.
7. Akarslan ZZ, Akdeveliog M, Gungor K, Erten H. A comparison of the diagnostic accuracy of bitewing, periapical, unfiltered and filtered digital panoramic images for approximal caries detection in posterior teeth. Dentomaxillofac Radiol 2008;37:458–63.

8. Scarfe WC, Langlais RP, Nummmikoski P, Dove B, McDavid WD, Deahl T, *et al*. Clinical comparison of two panoramic modalities and posterior bitewing radiography in the detection of proximal dental caries. Oral Surg Oral Med Oral Pathol 1994;77:195-207.
9. Goodarzi PD, Berijani N. Evaluation of the overlapping of posterior teeth in two techniques of improved interproximal panoramic program and standard panoramic. J Dent Med 2010;23:12-20.
10. White SC. Assessment of radiation risk from dental radiography. Dentomaxillofac Radiol 1992;21:118-26.
11. Tyndall DA, Ludlow JB, Platin E, Nair M. A comparison of Kodak Ektaspeed Plusfilm and the Siemens Sidexis digital imaging system for caries detection using receiver operating characteristics analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:113–8.
12. Douglass CW, Valachovic RW, Wijesinha A, Chauncey HH, Kapur KK, Mc Neil BJ. Clinical efficacy of dental radiography in the detection of dental caries and periodontal diseases. Oral Surg Oral Med Oral Pathol 1986;62:330-9.
13. Valachovic RW, Douglass CW, Reiskin AB, Chaunsey HH, McNeil BJ. The use of panoramic radiography in the evaluation of evaluation of asymptomatic adult dental patients. Oral Surg Oral Med Oral Pathol 1986;61:289-96.
14. Flint DJ, Paunovich E, Moore WS, Wofford DT, Hermesch CB. A diagnostic comparison of panoramic and intraoral radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:731–5.
15. Akarslan ZZ. Author's reply to the Letter to the Editor entitled ''Gold standard for the comparison of the diagnostic accuracy of panoramic images for approximal caries detection'' published in Dento maxillofacial Radiology (2009;38:245). Dentomaxillofac Radiol 2009;38:493; author reply 494.
16. Zhang Z, Qu X, Li G, Zhang Z, Ma X. The detection accuracies for proximal caries by cone-beam computerized tomography, film, and phosphor plates. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:103-8.
17. Felemban OM, Loo CY, Ramesh A. Accuracy of cone-beam computed tomography and extraoral bitewings compared to intraoral bitewings in detection of interproximal caries. J Contemp Dent Pract 2020;21:1361-7.