Clinical and radiographic diagnosis of approximal and occlusal dental caries in a low risk population

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ABSTRACT

Objective: Determine the agreement between visual detection, conventional radiology and digital radiology methods in the diagnosis of interproximal and occlusal caries in the posterior teeth of a group of patients with low caries prevalence.
Materials and Methods: Visual, conventional radiographic and digital radiographic (Digora®, Soredex, Sweden) caries diagnosis was performed in a group of patients (n=30) of both sexes with ages ranging from 15 to 65 years (x = 34 years). Agreement was estimated by the linear weighted kappa index.
Results: Kappa = 0.17 was obtained between the visual examination and the conventional radiographic examination and Kappa = 0.16 between the visual examination and the radiovisiography. Between conventional and digital radiography the Kappa indexes were 0.81 overall, 0.87 in the dentine and 0.66 in the enamel. Compared to visual examination, 3.23 times more caries lesions were diagnosed with digital radiology and 2.88 times more with conventional radiography. 94% of the new caries detected were interproximal.
Conclusions: The use of radiographic techniques, whether conventional or digital, increases the number of caries diagnosed in comparison with conventional clinical examination. The two radiographic techniques show high agreement in lesion diagnosis.

Key words: *Dental caries diagnosis, bite-wing radiography, digital radiology, Digora®.*

RESUMEN

Objetivo. Determinar la concordancia de los métodos de detección visual, radiológico convencional y radiológico digital en el diagnóstico de caries interproximales y oclusales en los dientes posteriores de un grupo de pacientes de prevalencia baja de la enfermedad.
Material y método. Se realizó el diagnóstico de caries visual y radiográfico convencional y digital (Digora®, Soredex, Sweden), en un grupo de pacientes (n = 30) de ambos sexos y edades comprendidas entre 15 y 65 años (x = 34 años). La concordancia se estimó mediante el índice Kappa ponderado lineal.
Resultados. Se ha obtenido un Kappa = 0.17 entre la exploración visual y la exploración radiográfica convencional, y un Kappa = 0.16 entre la exploración visual y la radiovisiografía. Entre la radiología convencional y la digital obtuvimos un índice Kappa = 0.81 globalmente, en la dentina 0.87 y en el esmalte 0.66. Se diagnosticaron 3.23 veces más lesiones de caries con la radiología digital y 2.88 con la radiografía convencional que con la exploración visual. El 94% de estas nuevas caries eran de localización interproximal.

Conclusiones. La utilización de técnicas radiográficas, ya sean convencionales o digitales, incrementa el número de caries diagnosticadas frente a la exploración clínica convencional. Ambas técnicas radiográficas se han mostrado muy concordantes en el diagnóstico de las lesiones.

Palabras clave: *Diagnóstico de caries dental, radiografía de aleta de mordida, radiografía digital, Digora®.*

INTRODUCTION

Dental caries is a high prevalence disorder and controlling it has been and is a very important health objective (1). Owing to the low severity of this disease, all the methods used to prevent and control it must be totally innocuous to the health of the target population.

Due to early caries diagnosis, the severity of the lesions has fallen in recent decades (2). The clinical pattern of caries is changing and slow progression of lesions, later cavitation and dentine affected below apparently sound enamel (3) are being observed, together with a higher prevalence in particular risk groups (1, 4, 5).

Visual examination and conventional radiography are diagnostic methods commonly employed by dentists. They have been joined by the new diagnostic techniques which have been made possible by digital radiological imaging, which can be combined with programs to assist decision-making (6); optic fibre backlighting and laser fluorescence have also contributed new aids to diagnosis (7). The fall in caries prevalence in industrialised countres has been accompanied by a rise in the percentage of interproximal caries, consequently, the examination method that is most-used and most effective for diagnosing lesions is bitewing radiography (4, 6, 8). Digital radiography adds new advantages to those of conventional methods, including speed and less radiation (3-4, 6, 9-13). Two digital X-ray systems have been developed: phosphorous plate systems and CCD (Charge Couple Device) systems (2, 4, 14-16).

The objective of this study is to determine the agreement between visual detection, conventional radiology and digital radiology methods in diagnosing interproximal and occlusal caries in the posterior teeth of a group of patients with low caries prevalence.

MATERIALS AND METHODS

The study sample was a group of 30 adult patients of both sexes, with ages ranging from 15 to 65 years (x=34 years), selected consecutively from patients attending the University of Valencia Dental Clinic who fulfilled the following criteria: over fourteen years of age, no milk teeth and agreement to undergo examination and give personal details (name, age and sex).

The same examiner examined each patient 3 times, conducting 1 clinical, 1 conventional radiographic and 1 digital radiographic examination. Each time, the interproximal and occlusal surfaces of premolars and molars were assessed and each of the surfaces was scored as described below.

In the clinical examination, a number 5 plain mouth mirror (Dentsply-Maillefer®, Ballaigues, Switzerland) was used to evaluate the caries status of each surface. The following codes were used (17): 1 (C1) Clinical lesion in intact enamel, such as white spot or brown spot with intact surface; 2 (C2) Lesion or small cavity, clinically detectable, confined to the enamel; 3 (C3) Caries lesion in dentine, detectable as present if any of the following signs were observed: evident cavitation, or pits and fissures strongly stained and extended with bottom softened, or pits, fissures and edges with enamel discoloured from lack of dentine support.

The radiographic examination evaluated the caries status from first premolar mesial to second molar distal by means of interproximal bitewing radiographs taken with the Depose model oral radiology machine (Trophy®, Kodak, USA) using a Kwik-Bite film holder (Hawe-Neos®, Kerr-Hawe, Switzerland). For the conventional radiographic examination, 35 mm x 45 mm D-speed Ultra-Speed intraoral X-ray film (Kodak®, Rochester, NY, USA) was used with a 0.32 second exposure time. For the digital radiographic examination, 30 mm x 40 mm white plates for Digora®, with disposable shields, were used for a 0.18 second exposure time. The X-rays were viewed at the end of the study, all on the same day, firstly the conventional radiographs on a wall-mounted negatoscope then the digital radiographs on the computer screen, using the toolbox in the same way for each (Digora® software for Windows 2.0®, Soredex®). The codes of Manji et al. (18) were employed for both these examinations, as follows: 1 (E1) Lesion in outer half of enamel; 2 (E2) Lesion in inner half of enamel; 3 (D1) Lesion in outer third of dentine; 4 (D2) Lesion in middle third of dentine; and 5 (D3) Lesion in inner third of dentine.

In order to compare the visual clinical examination with the two radiographic examinations, the categories required recoding. C1 in the clinical examination corresponded to the sound surface diagnosis of the X-ray examinations, C2 in the clinical examination was E1 and E2 in the radiographic methods and C3 of the clinical diagnosis covered codes D1, D2 and D3 in the radiological examinations.

Agreement was determined by the linear weighted kappa index and the data were analysed with SPSS 10.0®.

In this study, visual inspection, conventional radiography and digital radiography were compared to each other and the results for the interproximal and occlusal surfaces were analysed both jointly and separately.

RESULTS

1436 surfaces were studied: 478 occlusal and 958 interproximal.

On comparing the clinical examination with conventional radiography, the two methods were in agreement on a sound diagnosis for 1343 of the 1436 surfaces examined. 40 surfaces with caries in the enamel and 27 with caries in

the dentine were detected radiographically but not clinically. 12 surfaces with caries in the enamel and 6 with caries in the dentine that were observed visually were not diagnosed radiographically. 8 lesions were detected as carious by both methods.

On comparing the clinical examination with digital radiography, 1335 surfaces were diagnosed as free of caries by both methods. 46 surfaces with caries in the enamel and 29 with caries in the dentine were observed by digital radiography but not by clinical examination. 11 surfaces with caries in the enamel and 6 with caries in the dentine were found by visual examination but not diagnosed with digital radiography. 9 lesions were detected as carious by both methods.

Comparison of conventional and digital radiographic examination found that 1340 sound surfaces had been detected by both methods. 10 surfaces with caries in the enamel and 2 with caries in the dentine were detected by conventional radiography but not diagnosed in the digital examination. 16 surfaces with caries in the enamel and 5 with caries in the dentine were detected by digital radiographic examination but not observed with conventional radiology. 63 lesions were detected as carious by both methods.

In Table 1 it will be seen that agreement was very low both between the visual examination and the conventional radiographic examination (Kappa = 0.17) and between the visual examination and the radiovisiography (Kappa = 0.16). On comparing conventional and digital radiology, however, it will be observed that the agreement between the two methods was very high (Kappa = 0.81), although better in the dentine (Kappa = 0.87) than in the enamel (Kappa = 0.66). Caries diagnosis by the two radiological techniques shows agreement in both the occlusal surfaces (Kappa = 0.79) and the interproximal surfaces (Kappa = 0.80). As regards the comparison between clinical examination and either of the two radiological methods, agreement was very low for both the occlusal and the interproximal surfaces (see Tables 2 and 3).

Table 1. Agreement and Kappa index by category of examinations in occlusal and interproximal surfaces.

Comparison	*Category*	*Percentage agreement*	*Kappa*	*95% confidence interval*
Clinical examination vs. Conventional radiology	*Total*	95.82%	0.17069	0.0567 - 0.2847
	Sound	94.08%	0.13516	0.0386 – 0.2317
	Caries in enamel	96.24%	-0.1466	(-0.020) – (-0.009)
	Caries in dentine	97.56%	0.24593	0.0814 – 0.4105
Clinical examination vs. Digital radiology (Digora®)	*Total*	95.47%	0.16839	0.0614 - 0.2754
	Sound	93.59%	0.13985	0.0466 – 0.2331
	Caries in enamel	95.82%	-0.1518	(-0.021) – (-0.009)
	Caries in dentine	97.35%	0.23022	0.0735 – 0.3869
Conventional radiology vs. Digital radiology (Digora®)	*Total*	98.54%	0.81028	0.7438 - 0.8767
	Sound	97.70%	0.78033	0.7077 – 0.8529
	Caries in enamel	98.05%	0.66442	0.5478 – 0.7811
	Caries in dentine	99.37%	0.87350	0.7917 – 0.9553

Table 2. Agreement and Kappa index by category of examinations in occlusal surfaces.

Comparison	*Category*	*Percentage agreement*	*Kappa*	*95% confidence interval*
Clinical examination vs. Conventional radiology	*Total*	97.70%	0.0769	(-0.06)-0.2213
	Sound	96.65%	0.10445	(-0.091)-0.300
	Caries in enamel	97.49%	0.00	0.00-0.00
	Caries in dentine	98.74%	(-0.0056)	(-0.011)-0.00
Clinical examination vs. Digital radiology (Digora®)	*Total*	97.91%	0.2786	(-0.023)-0.5805
	Sound	96.86%	0.2020	(-0.040)-0.4442
	Caries in enamel	97.91%	0.00	0.00-0.00
	Caries in dentine	98.95%	0.4397	0.0335-0.8460
Conventional radiology vs. Digital radiology (Digora®)	*Total*	99.79%	0.7989	0.4135-1
	Sound	99.79%	0.7989	0.4135-1
	Caries in enamel	-	-	-
	Caries in dentine	99.79%	0.7989	0.4135-1

Table 3. Agreement and Kappa index by category of examinations in interproximal surfaces.

Comparison	*Category*	*Percentage agreement*	*Kappa*	*95% confidence interval*
Clinical examination vs. Conventional radiology	*Total*	94.89%	0.1962	0.0686-0.3239
	Sound	92.80%	0.1531	0.0485-0.2577
	Caries in enamel	95.62%	(-0.003)	(-0.009)-0.0013
	Caries in dentine	96.97%	0.2830	0.1026-0.4635
Clinical examination vs. Digital radiology (Digora®)	*Total*	94.36%	0.1801	0.060-0.2994
	Sound	91.96%	0.1370	0.0420-0.2337
	Caries in enamel	94.99%	(-0.004)	(-0.009)-0.0013
	Caries in dentine	96.76%	0.269	0.0950-0.4433
Conventional radiology vs. Digital radiology (Digora®)	*Total*	97.91%	0.8069	0.7386-0.8753
	Sound	96.66%	0.7741	0.6986-0.8496
	Caries in enamel	97.08%	0.6592	0.5412-0.7772
	Caries in dentine	99.16%	0.8780	0.7944-0.9616

DISCUSSION

For clinical examination for dental caries, the recommended method is preferably visual, with assistance from the probe only in exceptional cases, as the examination probe causes iatrogeny and can convey bacteria from one dental surface to another (17). Tveit et al. (19) considered that visual inspection is limited as regards the information it is capable of providing and in a study correlating the clinical findings of visual inspections to the histology it was found that 76% of the teeth classed as sound by visual methods already had caries in the enamel. Pitts (20), referring to the depth of the carious lesion, stated that the same caries lesion can be diagnosed visually as D1 or D3.

With reference to the comparison of clinical and radiological diagnoses, Poorterman et al. (8) found that in a sample of 17-year-olds, over half of those diagnosed clinically as sound were detected as having one or more caries in the interproximal dentine thanks to radiographic examination and that 25% of another sample of 23-year-olds diagnosed clinically as sound showed caries in the dentine in interproximal bitewing X-rays. Dove (21) concluded that radiography appears to be essential for diagnosing the totality of interproximal caries. For their part, Hopcraft and Morgan (22) found that most of the interproximal caries (between 67.1% and 77.1%) were only detected radiographically.

The present study diagnosed 3.23 times more caries lesions with digital radiology than by visual examination and 2.88 times more lesions with conventional radiography than visually, with 96% of these caries being detected interproximally. The digital radiology examination diagnosed 1.12 times more carious surfaces than the conventional radiology.

This study employed conventional D-speed Ultra-Speed film, which is the most suitable for detecting caries lesions in enamel, as it gives a clearer image with better contrast, although it has the drawback of requiring a 40% higher dose of radiation (9). D- and E-speed Ultra-Speed conventional films give fairly similar results (3). There is some controversy over comparisons between conventional and digital radiology. In vivo studies comparing the diagnoses of interproximal caries lesion depth made by the Digora® system and by interproximal radiography with E-speed Ultra-Speed film found that the caries lesion depth was underestimated with the digital image compared to conventional radiography; whereas in vitro studies found the two to be comparable. Further research is needed in this field (2).

Svanaes et al. (23) showed that digital images improved interproximal caries detection overall compared to conventional E-speed Ultra-Speed radiography and that the digital images showed significantly higher diagnostic exactness than conventional radiography as regards caries lesions in the outer half of the enamel. The present study diagnosed 1.33 times more caries in the outer half of the enamel and 0.9 times less in the inner half by digital radiology than by conventional radiography; in total, 1.15 times more caries in enamel were diagnosed by the digital system than by the conventional radiography.

Studies conducted in the mid 1990s asserted that conventional and digital radiography showed similar diagnoses of caries lesions in the inner half of the enamel or deeper (14), even explaining that conventional radiology is superior to radiovisiography for detecting small interproximal cavities in the enamel (10). The present study detected more caries lesions in the enamel and in the dentine by the digital system than by the conventional method. Digital radiology detected 1.11 times more caries in the outer third of the dentine and 1.07 in the middle third than conventional radiography, although the same number of caries lesions were detected in the inner third of the dentine. Haak et al. (4) considered that interproximal caries lesion detection is similar by the conventional and digital radiographic methods.

Svanaes et al. (23) considered that digital images have shown a comparable capacity to diagnose interproximal caries to that of conventional images, in both permanent and primary teeth. Compared to digital radiography, conventional radiography does not contribute significant differences in the detection of interproximal caries lesions in the enamel or the diagnosis of occlusal caries in the dentine (9). In the present study, when the two methods were compared by code the Kappa index value was lower for caries lesions in the enamel, although good agreement was found (Kappa = 0.66). However, as the depth of the lesions increased the Kappa value rose (Kappa = 0.87), showing very good agreement between the two radiological methods. Since this was an in vivo study its main limitation, as in similar cases, was the lack of a gold standard by which the diagnosis could be verified, such as an anatomicopathological study, which would have made it possible to conduct an examination of sensitivity and specificity rather than of agreement.

CONCLUSIONS

The use of radiographic techniques, whether conventional or digital, increases the number of caries diagnosed in comparison with conventional clinical examination.

The two radiographic techniques show high agreement in lesion diagnosis. This agreement is higher in dentine than in enamel.

The new digital radiology methods are an improvement in terms of the radiation used and may help to increase diagnostic capacity, although further studies will be needed to establish firmer conclusions in this respect.

REFERENCES

1. Marthaler TM. Changes in Dental Caries 1953-2003.Caries Res 2004; 38:173-81.

2. Versteeg KH, Sanderink GCH, Velders XL. 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; 84:210-3.

3. Rusell M, Pitts NB. Radiovisiographic Diagnosis of Dental Caries: Initial Comparison of Basic Mode Videoprints with Bitewing Radiography. Caries Res 1993;27:65-70.

4. Haak R, Wicht MJ, Noack MJ.Conventional, Digital and Contrast-Enhanced Bitewing Radiographs in the Decision to Restore Approximal Carious Lesions. Caries Res 2001;35:193-9.

5. Almerich Silla JM, Montiel Company JM. Oral health survey of the child population in the Valencia Region of Spain (2004). Med Oral Patol Oral Cir Bucal 2006;11:E369-81.

6. Duncan RC, Heaven T, Weems RA. Using computers to diagnose and plan treatment of approximal caries detected in radiographs. J Am Dent Assoc 1995;126:873-82.
7. Pereira AC, Verdonschot EH, Huysmans MC. Caries detection methods: can they aid decesion making for invasive sealant treatment?. Caries Res 2001;35:83-9.
8. Poorterman JHG, Aartman IHA, Kieft JA, Kalsbeek H. Value of bitewing radiographs in a clinical epidemiological study and their effect on the DMFS index. Caries Res 2000;34:159-63.
9. Hintze H, Wenzel A, Jones C. In vitro Comparison of D- and E- Speed Film Radiography, RVG, and Visualix Digital Radiography for the Detection of Enamel Approximal and Dentinal Occlusal Caries Lesions. Caries Res 1994;28:363-7.
10. Dagenais ME, Clark BG. Receiver operating characteristics of RadioVisioGraphy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:238-45.
11. Forner L, Llena MC, Almerich JM. Digital radiology and image analysis for approximal caries diagnosis. Oper Dent 1999;24:312-5.
12. Pfeiffer P, Schmage P, Nergiz I. Effects of different exposure values on diagnostic accuracy of digital images. Quintessence Int 2000;31:257-60.
13. Gakenheimer DC. The efficacy of a computerized caries detector in intraoral digital radiography. J Am Dent Assoc 2002;133:883-90.
14. Parks ET, Miles DA, Van Dis ML. Effects of filtration, collimation, and target-receptor distance on artificial approximal enamel lesion detection with the use of RadioVisioGraphy. Oral Surg Oral Med Oral Pathol 1994;77:419-26.
15. Svanaes DB, Moystad A, Risnes S. Intraoral storage phosphor radiography for approximal caries detection and effect of image magnification. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;82:94-100.
16. Velders XL, Sanderink GCH, Van der Stelt PF. Dose reduction of two digital sensor systems measuring file lengths. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:607-12.
17. Pitts NB. Current methods and criteria for caries diagnosis in Europe. J Dent Educ 1993;57:409-14.
18. Manji F, Fejerskov O, Baelum V. Pattern of dental caries in an adult rural population. Caries Res 1989;23:55-62.
19. Tveit AB, Espelid I, Fjelltveit A. Clinical diagnosis of occlusal dentin caries. Caries Res 1994;28:368-72.
20. Pitts NB. Clinical diagnosis of dental caries: a European perspective. J Dent Educ 2001;65:972-8.
21. Dove SB. Radiographic Diagnosis of Dental Caries. J Dent Educ 2001;65:985-90.
22. Hopcraft MS, Morgan MV. Comparison of radiographic and clinical diagnosis of approximal and occlusal dental caries in a young adult population. Community Dent Oral Epidemiol 2005;33:212-8.
23. Svanaes DB, Moystad A, Larheim TA. Approximal Caries Depth Assessment with Storage Phosphor versus Film Radiography. Caries Res 2000;34:448-53.