Afr. J. Med. med. Sci. (2010) **39**, 41 - 48

A comparison of clinical and radiographic caries diagnosis on posterior teeth of children seen at a Nigerian Teaching Hospital.

BO Popoola[1], OO Denloye[1], DM Ajayi[2] and EO Sote[3]

Departments of Child Oral Health[1], Restorative Dentistry[2], University College Hospital, Ibadan and Child Dental Health, Lagos University Teaching Hospital[3], Lagos, Nigeria.

Summary

Early detection and initiation of therapy for dental caries is the most effective means of ensuring resolution of the condition and its sequelae. The aim of this study was to compare the effectiveness of clinical and radiographic (using bitewing radiograph) methods of caries diagnosis in children. The subjects were 172 children within the age range of 5-12 years attending the Paedodontic Clinic of the University College Hospital for the first time. They were clinically examined for the presence of dental caries using the WHO criteria. Left and right bitewing radiographs were taken following the clinical examination to detect dental caries. Clinical examination found additional 4 occlusal caries (incipient caries) that were not diagnosed radiographically and radiographic examination revealed additional 20 approximal surface caries that were not evident clinically in deciduous teeth. In permanent teeth, 3 additional occlusal caries were diagnosed clinically while only one additional approximal caries was diagnosed radiographically. These observations revealed the additional diagnostic value of bitewing radiograph in the diagnosis of approximal caries in children and the importance of clinical examinations in diagnosis of early occlusal caries (incipient caries) which are difficult to see on dental radiographs. In view of these findings, the use of bitewing radiographs combined with careful clinical examination will be of great advantage in early detection of caries in children.

Keywords: *Dental caries, diagnosis, bitewing radiography.*

Résumé

La détection précoce et l'initiation de la thérapie des caries dentaires est l;un des moyens le plus efficace pour assurer la résolution de la condition et des séquelles. Le but de cette étude était de comparer les efficacités cliniques et radiographique des méthodes de diagnostic des caries chez les enfants. 172 enfants dans l'âge de 5-12 ans participant a la clinique pedodontique du centre Universitaire hospitalier d Ibadan; Nigeria pour la premier fois. Ils étaient examinés cliniquement utilisant es critères de l'OMS. La radiographie gauche et droite étaient prises pour analyser clinique de la présence des caries dentaires. L'examination montraient 4 cas de caries occlusales non diagnostiques par la radiographie et l examen radiographique révélaient 20 cas de surface a caries sans aucune évidence sur les dents. Sur les dents de sagesse, 3 caries occlusales additionnelles étaient diagnostiquées cliniquement pendant que une seule carie approximable additionnelle était diagnostique radiophicallement. Ces observations ont révélées la valeur diagnostique additionnelle de radiographies pendant le diagnostis descarieschezles enfants et l'importance des examinations cliniques en diagnostic des caries occlusales précoce qui sont difficiles a détecter par radiographie dentaire. En vue de ces recherches, l'utilisation des radiographes combinés avec des examinations cliniques soigneux seraient d un grand avantage dans la détection précoce de caries chez les enfants.

Introduction

Dental caries is one of the most common diseases in the world and it continues to be a common problem among children [1]. Controlling it has been a very important health objective [2]. In Nigeria, a number of epidemiological studies on the causes of tooth morbidity and mortality have shown that dental caries accounts for the largest percentage in children [3-6].

As with any disease process, early detection and early initiation of therapy for dental caries is the most effective means of ensuring resolution of the condition and its sequelae which include pulpitis, dento-alveolar abscess, premature tooth loss and poor feeding in children. In developed countries, due to early dental caries diagnosis, the severity of the lesions has fallen in recent decades [7]. However, the clinical pattern of caries is changing by the slow

Correspondence: B.O. Popoola, Department of Child Oral Health, University College Hospital, Ibadan, Nigeria

progression of lesion, followed by cavitation and dentinal lesion under apparently sound enamel [8,9]. Clinical examination and radiographic diagnostic methods are the most commonly employed means of caries diagnosis in this environment despite the invention of various new diagnostic techniques which include, digital imaging, fibreoptic backlighting and laser fluorescence in developed countries [10]. Caries epidemiological studies have traditionally been based on clinical examination alone [11], although a considerable number of studies have shown that this leads to underestimation of the occurrence of carious lesions in approximal and occlusal surfaces when compared with radiographic examination [12-16]. Although a fall in caries prevalence in industrialized countries has been observed, a slight rise in the percentage of approximal caries was also observed. Consequently, the use of bitewing radiography that has been found to be effective for detection of approximal caries was mandated for diagnosis of caries especially in children [9,17,18].

A number of studies on related clinical research reported that in the absence of radiographic examination, 1.2 – 32.2% of the total number of dentinal lesions in occlusal surface of young teenagers will go undetected [19-21] . Of approximal surfaces, about 0.1–1.6% of the dentinal lesions and 2.2–12.4% of the enamel lesions in age-matched children were not recorded by clinical examinations alone [21, 22]. However, a search into the literature shows a dearth of information on the comparison of clinical and radiographic caries diagnosis in Nigerian children generally and in the patients seen at the University College Hospital (UCH) Ibadan. Therefore, this study aimed at comparing clinical and radiographic methods of caries diagnosis using bitewing radiograph on posterior teeth of children aged 5–12 years.

Material and methods

The subjects were children aged 5 to 12 years attending the Paedodontic Clinic of the UCH Ibadan, for the first time .The study was conducted within a period of 24 months. All subjects within the age range who presented in the clinic, irrespective of their complaints were examined clinically and radiographically (using bitewing radiograph) for dental caries. Parental consent for routine clinical and radiographic examination was obtained before dental examination. Approval for the study was obtained from UI/UCH Ethical Review Committee.

Clinical examination and assessment.

Clinical examination for dental caries on posterior teeth of each child was carried out by the researcher using World Health Organization [11] criteria for diagnosis of caries. This involved sitting each patient on the dental chair and examining the posterior teeth of each child using sterile mouth mirrors and CPI probes (community periodontal Index probe) under the illumination attached to each chair .Each posterior tooth was dried with an air jet to facilitate detection of early carious lesion (white lesion) . A tooth was considered "sound" when it showed no evidence of treated or untreated caries clinically. A tooth with discoloured or rough spots that were not soft to touch with a blunt probe and stained pits or fissures in the enamel that did not have visual signs of undermined enamel or softening of the floor or walls using a blunt probe were also considered sound. A tooth was said to be carious when there was a cavity in its pits, fissure or smooth surface, if there was undermined enamel or a detectable softened floor or wall using the blunt probe. A tooth with chalky white spots when it was dried with air jet was considered carious clinically (Incipient Caries). Three surfaces (occlusal, mesial and distal approximal surfaces) of each tooth were examined and the surfaces affected by caries were noted and recorded. Buccal and lingual surfaces of these teeth were not considered due to super-imposition of pulp radiolucency on carious lesions radiographically.

When a tooth has one or more restoration on it, it was recorded as "filled" tooth. However, a tooth was considered "missing" due to caries when it was extracted as a result of caries. Missing Primary teeth, were not considered missing due to caries until when normal exfoliation would not be a sufficient explanation for its absence in that age.

Radiographic examination and assessment.

A set of standard posterior bitewing radiographs were taken by the researcher for each child previously examined clinically using Kodak ultra-speed film (size: 31 x 41mm, speed: group D, batch number: 3903001803 – 1 and ISO number: CE0473) and a wall mounted, long plastic, open-ended cylinder with inner metallic collimator (EKV 2mmAL) X-ray machine (Buckingham Plh Medical limited, Chirana model).

To standardize exposures, kwik-bite film holders (KerrHawe Dental, Bioggio, Switzerland) were used. All the X-ray films were manually processed using AGFA G230 (batch number 6K01133) as developer and AGFA G305(batch

number 6K01142) as fixer. These radiographs were then assessed with the aid of a viewing box placed in a darkened viewing room. This assessment was carried by the researcher without the knowledge of the previous clinical records. Prior to this radiographic assessment, calibration of the researchers' radiographic assessment skill on dental caries was carried out by a senior colleague who is more experienced in interpretation of dental radiographs. Assessment for dental caries was carried out using modifying Downer [23] criteria for radiographic examination of dental caries as follows:
A tooth was considered

Sound	when there was no radiolucent area in enamel and or dentine.
Occlusal caries	when there was radiolucency in either enamel and or dentine on the occlusal surface.
Approximal caries	when there was radiolucent area in either enamel and or dentine on the mesial or distal surface without direct continuation with the occlusal surface

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 11.0.Test for significance between categorical variables in the data were determined using Pearsons Chi square (X^2) test with statistical significance set at $p \leq 0.05$. The level of agreement of the two diagnostic methods was determined by linear weighted kappa index.

Results

During the 24 - month study period, a total of 172 children, within the age range of 5-12 years attending the Paedodontic Clinic UCH, Ibadan for the first time were seen.

There were 108 children aged 5-8 years [55 males (50.9%); 53 females (49.1%)] and 64 children aged 9-12 years [38 males (59.4%); 26 females (40.6%)] .Distribution of both deciduous and permanent teeth in the subjects are as shown in Tables 1 and 2 respectively. Also from Table 1, decayed (d) deciduous teeth observed were 245 clinically while 261 were observed radiographically. In the permanent dentition, decayed teeth (D) observed were 74 clinically and 72 radiographically.

As shown in Figure 1, most of the subjects (73.8%) had dental caries while 26.2% were caries free. Of 127 children with dental caries, 69 (54.3%) were male while 58 (45.7%) were female (figure 2). The male to female ratio of children with dental caries is 1.2: 1. There was no statistically significant association between gender and the prevalence of caries (p=0.158). The prevalence of caries in age

Table 1: Tooth type distribution of decayed, missing and filled deciduous teeth for clinical and radiographical examinations

Tooth type	n_t	Clinical				Radiographic			
		Decayed teeth "d"	Missing teeth "m"	Filled teeth "f"	Total dmft	Decayed teeth "d"	Missing teeth "m"	Filled teeth "f"	Total dmft
54	59	15	3	-	18	17	3	-	20
55	61	27	-	-	27	28	-	-	28
64	60	13	2	-	15	15	2	-	17
65	61	26	1	-	27	27	1	-	28
74	60	35	1	-	36	38	1	-	39
75	60	42	1	-	43	45	1	-	46
84	60	40	-	-	40	42	-	-	42
85	60	47	1	-	48	49	1	-	50
Total	481	245	9	-	254	261	9	-	270

n_t = total number of deciduous posterior teeth examined.

Intra-examiner reliability

The intra-examiner reliability (kappa) of clinical examination and radiographic assessment for caries was determined by the researcher using the first 20 children (without acute symptoms) for clinical examination and 20 sets of randomly selected bitewing radiographs for the radiographic examination. These patients and the radiographs were re-examined and reassessed 2 weeks after the initial examination. Weighted kappa scores were estimated based on duplicate recordings using SPSS (version 11.0).

group 5-8years was 71% while that of age group 9-12years was 78% (figure 3), this was statistically significant (p=0.001).

In Table 3, on clinical and radiographic examination, 1443 posterior deciduous teeth surfaces were examined (481 occlusal surfaces and 962

Fig. 1: Dental caries prevalence among children seen at the dental clinic

Fig. 2: Gender distribution of caries prevalence.

Fig. 3: Age distribution of caries prevalence.

Table 2: Tooth type distribution of decayed, missing and filled permanent teeth for clinical and radiographical examinations

Tooth type	n_t	Clinical				Radiographic			
		Decayed teeth "D"	Missing teeth "M"	Filled teeth "F"	Total DMFT	Decayed teeth "D"	Missing teeth "M"	Filled teeth "F"	Total DMFT
16	43	12	1	-	13	13	1	-	14
17	2	-	-	-	-	-	-	-	-
26	43	16	-	-	16	15	-	-	15
27	2	1	-	-	1	-	-	-	-
36	46	20	-	-	20	19	-	-	19
37	2	1	-	-	1	1	-	-	1
46	46	24	-	-	24	24	-	-	24
47	2	-	-	-	-	-	-	-	-
Total	186	74	1	-	75	72	1	-	73

n_t = total number of permanent posterior teeth examined.

Table 3: Surface prevalence of caries in deciduous teeth on clinical and radiographical examinations according to tooth type.

Tooth type	No. of teeth examined "n_t"	Total No. of surfaces examined "n, x 3"	Clinical examination			Radiographical examination		
			Occlusal surface caries	approximal surface caries	Non carious surfaces	Occlusal surface caries	approximal surface caries	Non carious surfaces
54	59	177	6	13	158	6	15	156
55	61	183	18	11	154	17	13	153
64	60	180	6	7	167	6	9	165
65	61	183	14	14	155	12	17	154
74	60	180	11	27	142	11	30	139
75	60	180	20	26	134	19	30	131
84	60	180	8	35	137	8	37	135
85	60	180	24	28	128	24	30	126
Total	481	1443	107	161	1175	103	181	1159

n_t = number of posterior deciduous teeth examined ,while 3 represents the number of surfaces examined per tooth (occlusal, mesial and distal approximal surfaces).

approximal surfaces). Clinical examination found 268 carious surfaces (107 occlusal caries and 161 approximal caries) while radiographic examination revealed 284 carious surfaces (103 occlusal caries and 181 approximal caries). On comparing clinical examination findings with radiographic examination, clinical examination found additional 4 occlusal caries that were not diagnosed radiographically and radiographic examination found additional 20 approximal surface caries that were not evident clinically. Likewise, 558 posterior permanent teeth surfaces were examined clinically and radiographically for caries (Table 4). Clinical examination found 78 carious surfaces (57 occlusal caries and 21 approximal caries) while radiographic examination revealed 76 carious surfaces (54 occlusal caries and 22 approximal caries). This result showed that, three additional occlusal surface caries were diagnosed clinically while only one additional approximal caries was diagnosed radiographically in the permanent teeth. As shown in Table 5, the level of agreement between the two diagnostic methods was more significant for occlusal caries (Kappa=0.925) than for approximal caries (Kappa=0.610) in deciduous teeth while in permanent teeth, the level of agreement between the two

diagnostic methods for both occlusal and approximal caries were similar and highly significant (kappa=0.959 and 0.980 for occlusal and approximal caries respectively).

In deciduous teeth, the teeth mostly affected by approximal caries were lower deciduous molars, while the surfaces mostly affected in approximal caries were distal surfaces of first deciduous molars and mesial surfaces of second deciduous molars.

The weighted Kappa scores for intra-examiner variabilities for both clinical and radiographic examinations were high (kappa = 0.920 and 0.942 for clinical and radiographic examinations respectively). These show good levels of agreements in the findings of the researcher at different times of examination of same subject and same set of radiographs.

Discussion

With the knowledge that dental caries progression is more rapid in primary teeth [24], accurate and early detection of carious lesions is of clinical significance in paediatric dentistry. The early detection of incipient proximal caries is essential because of the rapid rate of progression of such lesion in primary teeth and the comparatively short distance between the external surface of the tooth and the pulp [25]. However, in spite of the invention of various high-technology devices, diagnosis of caries is still very much dependent on clinical examination (visual inspection and use of explorer) in this environment due to very high cost of the various new devices.

The present study has considered the two most widely used dental caries detection techniques, in diagnosis of occlusal and approximal caries in

Table 4: Surface prevalence of caries in permanent teeth on clinical and radiographical examinations according to tooth type

Tooth type	No. of teeth examined "n_t"	Total No. of surfaces examined "n_t x 3"	Clinical examination			Radiographical examination		
			Occlusal surface caries	Approximal surface caries	Non carious surfaces	Occlusal surface caries	Approximal surface caries	Non carious surfaces
16	43	129	11	1	117	11	2	116
17	2	6	-	-	6	-	-	6
26	43	129	13	3	113	12	3	114
27	2	6	1	-	5	-	-	6
36	46	138	13	8	117	12	8	118
37	2	6	1	-	5	1	-	5
46	46	138	18	9	111	18	9	111
47	2	6	-	-	6	-	-	6
Total	186	558	57	21	480	54	22	482

n_t = number of posterior permanent teeth examined; while 3 represents the number of surfaces examined per tooth (occlusal, mesial and distal approximal surfaces).

Table 5: Percentage agreement and Kappa index between clinical and radiographic examinations in deciduous and permanent teeth in diagnosis of occlusal and approximal surface caries

	Deciduous teeth			Permanent teeth		
	Percentage agreement (%)	Kappa	95% Confidence interval	Percentage agreement (%)	Kappa	95% Confidence interval
Occlusal surface caries	96.26	0.925	0.0204 -0.0809	94.73	0.959	0.0614 - 0 .2750
Approximal surface caries	88.95	0.610	0.0742 -0.0870	95.45	0.980	0.0466 – 0.2310
Sound surfaces	98.60	0.987	0.0791 -0.0952	99.58	0.990	0.4350 - 0.7890

children. Although it appeared that the number of carious deciduous and permanent teeth observed radiographically was relatively about the same as those observed clinically, actual findings showed four cases of occlusal incipient caries on deciduous teeth and three cases of such lesion on permanent teeth during clinical examination and these were not evident on the bitewing radiographs. This observation is as a result of superimposition of dense buccal and lingual enamel cusps, making early occlusal carious lesions (incipient occlusal caries) difficult to see on dental radiographs [15]. Thus it implies that both clinical and radiographic methods are important especially in diagnosis of occlusal lesions if a number of initial lesions potentially indicated for non-operative treatment (preventive therapy) will be diagnosed.

Similarly, the number of cavitated carious lesions on occlusal surfaces observed using bitewing radiograph alone was about the same as that observed by clinical examination only. This finding showed that bitewing radiograph has no additional diagnostic value in detection of occlusal caries (incipient or cavitated) in both deciduous and permanent teeth as was reported by Machiulskiene *et al.* [15]. The authors reported that the contribution of bitewing radiograph was minimal in diagnosis of occlusal caries, irrespective of the diagnostic level considered. This observation might have been due to easy access to occlusal surfaces of these teeth for visual and tactile examinations.

However, it was only with respect to approximal surface caries of deciduous and permanent teeth that bitewing radiographs detected more carious lesions than during clinical examination. This observation was in line with the conclusion reached by Kidd and Pitts [12] in their comprehensive review of results of 29 related studies. They concluded that the use of bitewing radiograph is essential if much approximal caries will not be undiagnosed.

The additional diagnostic value of bitewing radiograph observed in diagnosing approximal carious lesions in this study was in accordance with other studies [21, 22]. These authors unanimously reported that in approximal surface caries, about 0.1-1.6% of dentinal lesions and 2.2-12.4% of the enamel lesions were not recorded by clinical examinations alone. Pitts [14], in his study also concluded that clinical examination alone generally detected < 50% of the total approximal lesions found with both methods while bitewing radiographs used alone ,generally detected >90% of the total number of the total number of approximal lesions. This observation is in agreement with the findings of this study where more approximal carious lesions were observed radiographically in both dentitions. These findings therefore confirmed that bitewing radiograph has better diagnostic value as far as diagnosis of approximal surface caries is concerned.

The observed high level of agreement between clinical examination and bitewing radiographic findings in diagnosis of caries in deciduous and permanent teeth in this study showed that clinical examination could be assumed to have a high diagnostic value also, however the additional diagnostic value of bitewing radiograph in deciduous teeth found in this study cannot be disregarded. In a related study carried out in the older age group, it was found that in a sample of 17- year-olds, over half of those teeth diagnosed clinically as sound were detected as having one or more caries in their approximal surfaces and 25% of teeth of another sample of 23-year-olds diagnosed clinically as sound showed caries in the approximal surfaces on their bitewing radiographs [18].

In view of the observations in this study, the use of bitewing radiograph combined with careful clinical examination will be of great advantage in early detection of caries in children.

Conclusion

The use of bitewing radiograph increases the chance of early detection of caries in children when compared with clinical examination alone especially in the approximal surfaces and such lesions may respond to non operative treatments thereby improve the ability of children to cooperate when receiving dental treatment. In conclusion, bitewing radiograph should be used as an adjunct to clinical examination for diagnosis of caries in children.

References

1. Warren JJ, Hand JS and Yao JH. First molar caries experience among Taiwanese first grade children. ASDC J Dent Child 1997; 64:425-428.
2. Marthaler TM. Changes in Dental caries 1953-2003. Caries Res 2004; 38: 173-81.
3. Kekere-Ekun TA and Adenubi JO. The pattern of exodontia in children treated at Lagos University Teaching Hospital. Nigerian Dental Journal 1985; 6: 10-19.
4. Abiose BO. Dental problem of the Nigerian child. Nig Med J 1986; 17: 65 – 70.
5. Odusanya SA. Age and Sex distribution of tooth mortality among Nigerians. West Afr J Med 1989; 8(1):50 – 53.

6. Jeboda SO. Deciduous tooth loss in Nigerian Children. Pediatr Dent J 1991; 1:195–200.
7. Versteeg KH, Sandermk GCH and Velders XL. *In vivo* study of approximal caries depth on storage phosphor plate images compared with dental Xray film. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997; 84: 210-213.
8. Rusell M and Pitts NB. Radiovisiographic Diagnosis of Dental caries: initial comparison of Basic mode videoprints with Bitewing Radiography. Caries Res 1993; 27: 65-70.
9. Haak R, Wicht MJ and Noack MJ. Conventional Digital and contrast Enhanced Bitewing Radiographs in the decision to restore approximal carious lesions. Caries Res 2001; 35: 193-199.
10. Pereira AC, Verdonschot EH and Huysmans MC. Caries detection methods: can they aid decision making for invasive sealant treatment? Caries Res 2001; 35: 83-89.
11. World Health Organization. Oral Health surveys. Basic methods 4th edition. Geneva 1987. Cited by Kidd EAM, Pitts NB .A reappraisal of the value of bitewing radiograph in the diagnosis of posterior approximal caries. Br Dent J 1990; 169: 195–200.
12. Kidd EAM and Pitts NB. A reappraisal of the value of bitewing radiograph in the diagnosis of posterior approximal caries. Br Dent J 1990; 169: 195–200.
13. Skold UM, Klock B and Lindvall AM. Differences in caries recording with and without bitewing radiographs. Swed Dent J 1997; 21:69-75.
14. Pitts NB. The use of bitewing radiographs in the management of dental caries. Scientific and practical considerations. Dentomaxillofac Radiol 1996; 25(1): 5–16.
15. Machiulskiene V, Nyvad B and Baelum V. A comparison of clinical and radiographic caries diagnosis in posterior teeth of 12 year old Lithuanian children. Caries Res 1999; 33:340-348.
16. Denloye OO, Ajayi D and Bankole O .A study of dental caries prevalence in 12-14 year old school children in Ibadan, Nigeria. Pediatr Dent J 2005; 15(2):147-151.
17. Duncan RC, Heaven T and Weems RA. Using computers to diagnose and plan treatment of approximal caries detected in radiographs. J Am Dent Assoc 1995;126: 873-882
18. Poorterman JHG, Aartman IHA, Kieft JA and Kalsbeek H. Value of bitewing radiographs in a clinical epidemiological study and their effect on the DMFS index. Caries Res 2000; 34:159-163.
19. Creanor SL, Russel J, Strang DM, Stephen KW and Burchel CL . The prevalence of clinically undetected occlusal dentine caries in Scottish adolescents. Br Dent J 1990; 169: 126 – 129.
20. Kidd EAM, Naylor MN and Wilson RF. Prevalence of clinically undetected and untreated molar occlusal dentine caries in adolescent on the Isle of Wight. Caries Res 1992; 26:397 – 401.
21. Hintze H and Wenzel A, Jones. In-vitro comparison of D and E speed film radiography, RVG and visualix digital radiography for detection of enamel approximal and dentinal occlusal caries lesion. Caries Res 1994; 28: 365 – 367.
22. Pitts NB and Rimer PA. An in-vivo comparison of radiographic and directly assessed clinical caries status of Posterior approximal surfaces in primary and permanent teeth. Caries Res 1992; 26: 146 – 152.
23. Downer MC. Validation of methods used in dental caries diagnosis. Int Dent J 1989; 39:241-246
24. Rogers C and Hector M. The establishment of current opinion within consultants in paediatric dentistry in the UK for the taking of dental radiographs in children. Int J Paediatr Dent 1997; 7: 191 – 198.
25. Denloye OO, Dosumu OO and Arotiba J T . Causes and pattern of tooth extraction in children treated at the University College Hospital Ibadan. West Afr J Med 1999; 18: (4) :261 – 264.

Received: 12/05/09
Accepted: 15/03/10