Article published online: 2021-11-01

Original Article

Evaluation of the Interpretation of Bitewing Radiographs in Treating Interproximal Caries

Hila Hajizadeh[1,2], Majid Akbari[1,2], Seyed Hosein Hoseini Zarch[3,4], Atefeh Nemati-Karimooy[1,2], Azadeh Izadjou[5]

[1]Dental Research Center, Mashhad University of Medical Sciences, Departments of [2]Restorative and Cosmetic Dentistry and [3]Oral and Maxillofacial Radiology, School of Dentistry, Mashhad University of Medical Sciences, [4]Dental Materials Research Center, Mashhad University of Medical Sciences, [5]Private Researcher, Farhangian Clinic, Mashhad, Iran

Abstract

Objective: Misinterpretation of bitewing radiographs may lead to the selection of surgical approach rather than medical approach in treating proximal caries lesions. We aimed to determine the sensitivity, specificity, and diagnostic accuracy of bitewing radiography interpretation by various groups of dentists for the detection of proximal caries and subsequent treatment decision-making. **Materials and Methods:** This *in vitro* study was performed using 60 extracted molar and premolar teeth. The target proximal carious surfaces were categorized and coded according to the International Caries Detection and Assessment System (ICDAS) as category 1: ICDAS = 0, category 2: ICDAS = 1 or 2, and category 3: ICDAS = 3, 4, or 5. All the teeth were randomly divided and mounted onto 15 quadrants made of two premolars and two molars, and a digital bitewing image was taken from each quadrant. A checklist was given to four groups of participants (dentistry students, dentists with a DDS degree, restorative dentistry specialists, and oral radiology specialists) to indicate for which lesion depth they would intervene restoratively. The data acquired through the checklists were compared with direct visual examination of target surfaces before mounting. **Results:** Sensitivity and accuracy of bitewing radiography showed no significant difference among the groups. However, specificity was significantly higher in Group D. **Conclusions:** According to our results, interpretation of bitewing radiographs was different among the groups. Although not significant, the radiologists had the highest diagnostic accuracy than the other groups of participants, and the students showed the weakest performance in the diagnosis of restorative treatment needed. Furthermore, the highest percentage of decision error occurred when lesions had ICDAS 1 or 2, followed by ICDAS 3, 4, or 5, and finally 0 in all the four groups.

Keywords: Bitewing radiographs, interpretation, interproximal caries

Introduction

To provide the most beneficial treatment to accommodate to a given level of current risk and probable future risk, dentists must be able to reasonably assess the presence and severity of all carious lesions, tooth surface cavitation status, caries risk, and outcome probabilities for treatment regimens.[1]

In many recent studies, success in stopping active caries through health education and recommendation of the regular use of fluoride products such as toothpaste and mouthwash has been noticeable.[2,3] This shows the fundamental importance of accurate diagnosis to choose the preventive measures leading to avoid the need for surgical treatment.[4]

Among the different types of carious lesions, interproximal caries is infamous for their rapid rate of progression and difficulty in determining them.[5] In addition to clinical examination, different paraclinical diagnostic methods have been introduced to identify these lesions and determine the need for surgical or nonsurgical prophylactic treatments.

Some methods such as laser fluorescence and light-induced fluorescence are quantitative. It seems that quantitative methods could improve reliability because they would provide a metric, and the dentist would interpret this value using a predetermined cutoff point independent from clinician opinion.[6] The point

Access this article online

Quick Response Code:

Website: www.ejgd.org

DOI: 10.4103/ejgd.ejgd_99_18

Address for correspondence: Dr. Atefeh Nemati-Karimooy, Dental Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.
Department of Restorative and Cosmetic Dentistry, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.
E-mail: nematika@mums.ac.ir

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Hajizadeh H, Akbari M, Zarch SH, Nemati-Karimooy A, Izadjou A. Evaluation of the interpretation of bitewing radiographs in treating interproximal caries. Eur J Gen Dent 2019;8:13-7.

is that even using these quantitative methods, a clinician is faced with a range of therapeutic decisions (from medical to surgical methods), which are dependent on enamel ability of remineralization when still no cavitation is established.

Bitewing radiography is one of the most common paraclinic methods used in detecting and diagnosing interproximal lesions.[7] Unfortunately, radiography is not a quantitative method and lacks digital limits.[8] Some clinicians expect radiographic methods to estimate the depth and monitor the behavior of cavities.[7] In fact, evaluating the extent and depth of radiolucent area for surgical intervention is highly dependent on the clinician's interpretation. This judgment of the clinician is hinged on multiple factors such as training, skill, and even regional health culture and might increase unnecessary therapeutic interventions; it also affects health economics and dental health.[9] It is shown that interproximal overtreatment can damage the adjacent tooth and consequently cause therapeutic problems.[10]

Bitewing radiographs might mislead clinicians toward an unnecessary surgical intervention. Some demineralized lesions preserve their potential of remineralization while they are misinterpreted as active lesions in radiographic images. The evaluation of sensitivity and specificity of these paraclinical methods is one of the ways of determining their confidence limit.

Whereas interpretation of a radiographic image is highly person dependent, it is difficult to assign a specific value for the sensitivity, specificity, and diagnostic accuracy of radiographic techniques. However, a diagnostic method can be generalized and used by different groups of clinicians only if the responsibility of judgment will not merely depend on the clinician. Otherwise, objective criteria will be used to decide between surgical and clinical approach. The null hypothesis of this study was that there are no differences in sensitivity, specificity, and accuracy of bitewing radiographs interpretation among various groups of clinicians.

Materials and Methods

This *in vitro* study was performed using a number of molar and premolar teeth extracted for periodontal or orthodontic reasons. The teeth were completely cleaned of calculus and debris and then disinfected in 2% sodium hypochlorite solution for 20 min and stored in distilled water. Afterward, the teeth were clinically examined using no. 23 explorer (shepherd's hook) by two independent examiners.

One of the proximal surfaces of each tooth was coded according to the International Caries Detection and Assessment System (ICDAS). The teeth with ICDAS score 6 were excluded. Then, the teeth were divided into three categories of category 1: ICDAS = 0, category 2: ICDAS = 1 or 2, and category 3: ICDAS = 3, 4, or 5. The teeth were randomly selected from each category. Finally, 30 molars and 30 premolars were collected that included 22 surfaces with ICDAS score of 0, 19 surfaces with ICDAS score of 1 or 2, and 19 surfaces with ICDAS score of 3, 4, or 5.

All the teeth were randomly divided into 15 quadrants containing four teeth (two premolars and two molars). The teeth of each quadrant were mounted onto a mixture of soil and plaster (50% each) in water to imitate the alveolar bone considering correct anatomy and angulation of the teeth. Oral soft tissue was simulated by dental wax.

Then, digital bitewing radiographs were taken under standardized conditions by an intraoral unit (Planmeca, Finland) with long cone collimator (mA = 8, Kvp = 60, t = 0.1s) and film holders (Kerr, US). Radiographs were digitalized by PSP Durr Dental receptor (Vista Scan, Germany). The angle of collimator was about 7–8° positive, which is within the standard limit. The images were printed using a printer (Konica Minolta837, Japan) with 640 DPI resolution and two-fold magnification. Each radiographic image showed only one quadrant (without the teeth of the opposite arch). A checklist was given to four groups of participants while they were asked to indicate for which lesion depth they would intervene restoratively. The four groups of participants, who consented to participate in the study, were Group A: dentistry students attending the tenth semester (n = 20), Group B: dentists with a DDS degree and 5–10 years of work experience (n = 20), Group C: restorative dentistry specialists (n = 20), and Group D: oral radiology specialists (n = 7). The data acquired through checklists were compared with direct visual examination of target surfaces before mounting. In the third category, the selection of restorative treatment and in the categories 1 and 2, no restorative intervention were considered as appropriate answers according to the ICDAS restorative suggestions. To analyze the data, descriptive statistics and Chi-square test were used in SPSS, version 11.5 software (SPSS, Chicago, IL, USA).

Results

The number and percentage of "Yes" and "No" answers are shown in Tables 1-4 separated based on the group. Sensitivity, specificity, accuracy, as well as positive and negative predictive values related to X-ray are compared among the groups in Table 5. The percentage of false-positive and false-negative cases is presented in Table 6. Furthermore, Table 7 shows the percentage of decision error for restorative intervention in each group. As obvious, the highest percentage of error occurred in category 2, followed by 3 and 1 in all the four groups.

Discussion

According to the results of this study, various groups of participants interpreted a bitewing radiograph differently. Our results showed that, although not significant, radiologists had the highest diagnostic accuracy than the other groups of participants, and students showed

Table 1: Assessment of restorative treatment need by Group A (dentistry students)

Restorative treatment need	Interproximal assessment			Total
	Category 1 (%)	Category 2 (%)	Category 3 (%)	
Yes	94 (21)	134 (35)	284 (75)	512
No	346 (79)	246 (65)	96 (25)	688
Total	440 (100)	380 (100)	380 (100)	1200

Category 1 – ICDAS=0, Category 2 – ICDAS=1 or 2, Category 3 – ICDAS=3, 4, or 5.(ICDAS: International Caries Detection and Assessment System)

Table 2: Assessment of restorative treatment need by Group B (dentists with a DDS degree)

Restorative treatment need	Interproximal assessment			Total
	Category 1 (%)	Category 2 (%)	Category 3 (%)	
Yes	79 (18)	159 (42)	305 (80)	543
No	361 (82)	221 (58)	75 (20)	657
Total	440 (100)	380 (100)	380 (100)	1200

Category 1 – ICDAS=0, Category 2 – ICDAS=1 or 2, Category 3 – ICDAS=3, 4, or 5. (ICDAS: International Caries Detection and Assessment System)

Table 3: Assessment of restorative treatment need by Group C (restorative dentistry specialists)

Restorative treatment need	Interproximal assessment			Total
	Category 1 (%)	Category 2 (%)	Category 3 (%)	
Yes	80 (18)	131 (34)	307 (81)	518
No	360 (82)	249 (66)	73 (19)	682
Total	440 (100)	380 (100)	380 (100)	1200

Category 1 – ICDAS=0, Category 2 – ICDAS=1 or 2, Category 3 – ICDAS=3, 4, or 5. (ICDAS: International Caries Detection and Assessment System)

Table 4: Assessment of restorative treatment need by Group D (oral radiology specialists)

Restorative treatment need	Interproximal assessment			Total
	Category 1 (%)	Category 2 (%)	Category 3 (%)	
Yes	9 (6)	34 (26)	107 (80)	150
No	145 (82)	99 (74)	26 (20)	270
Total	154 (100)	133 (100)	133 (100)	420

Category 1 – ICDAS=0, Category 2 – ICDAS=1 or 2, Category 3 – ICDAS=3, 4, or 5. (ICDAS: International Caries Detection and Assessment System)

the weakest performance in the diagnosis of restorative treatment needed. Furthermore, the highest percentage of error occurred when the lesions had ICDAS 1 and 2, followed by ICDAS 3, 4, 5, and 0 in all the four groups. As mentioned earlier, four groups of participants were included in our study. Unfortunately, the number of dental radiology specialists was less than others. It was because of the limited number of radiologists who consented to participate in the study, all of whom were included and provided us a sample size of seven in this group.

It is believed that to interpret a radiographic image, clinicians should have the two skills needed for visual diagnosis, namely, the ability to recognize abnormal patterns, which is called perception and ability to interpret these patterns to reach a true diagnosis.[11]

Many factors may affect the interpretation of bitewing radiographs. Radiographic artifacts, film density, and other environmental and observer variables are some major problems in the interpretation of a radiographic image.[12] Even the diagnostic strategy, which might be analytic or nonanalytic reasoning, can affect one's interpretation. Other effective factors might be education level and experimental viewpoint of the clinician.[9,13] However, it is supposed that the main problem might not be finding a lesion in a radiographic image but rather the decision-making path regarding restoration of the lesion.

In this study, the decisions of participants to restore a surface were compared to the gold standard, which was restoring the surfaces with ICDAS = 3–5 (surfaces with enamel breakdown to cavitation) and not restoring the surfaces with ICDAS = 0–2 (healthy and discolored surfaces).

According to the results of our study, the greatest significant difference among the groups exists in students regarding the diagnosis and decision-making for noncavitated tooth surfaces that do not require restorative treatment. The low work experience of the final-year students might have probably caused the present results. General dental practitioners were in the next rank after students, which mean that the probability of overtreatment is higher in general dental practitioners and students. It might show the need for extensive training and review sessions regarding treatment planning of interproximal lesions in general practitioners.

Along with the results of our study, Neuhaus *et al*. noted that although radiography is very useful in improving the accuracy and sensitivity of diagnosis, work experience is required in the interpretation of the obtained results.[14] On the other hand, radiologists showed significantly better performance in the diagnosis of noncavitated surfaces. They were mainly faculty members of Mashhad School of Dentistry with up-to-date expertise due to constant teaching. Therefore, they understand artifacts and other problems better due to their knowledge of the process of taking X-rays. For instance, there are some visual effects that can mislead a clinician toward a lesion such as a cervical burnout or the Mach band effect. Perhaps, it is better to put more emphasis on artifacts and other similar problems in the science of radiology for students. However, regarding cavitated tooth surfaces, they were similar to other groups, which might be because the radiographic method is more efficient for the detection of more advanced caries lesions.[15]

Table 5: Comparison of sensitivity, specificity, accuracy, and positive and negative predictive values related to bitewing X-rays between groups

	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value
Group A	0.75	0.72[a]	0.73	0.55	0.86
Group B	0.80	0.71[a]	0.74	0.56	0.88
Group C	0.81	0.74[a]	0.76	0.59	0.89
Group D	0.80	0.85[b]	0.84	0.71	0.9
P	0.147	<0.001	0.572		

Group A – Dentistry students, Group B – Dentists with a DDS degree, Group C – Restorative dentistry specialists, Group D – Oral radiology specialists. ($P<0.05$)

Table 6: The percentage of false-positive and false-negative cases in each group

	Group A	Group B	Group C	Group D
False positive	27.80	29.02	25.73	14.98
False negative	25.26	19.73	19.21	19.54

Group A – Dentistry students, Group B – Dentists with a DDS degree, Group C – Restorative dentistry specialists, Group D – Oral radiology specialists

Table 7: The percentage of decision error for restorative intervention in each group

Group	Category		
	Category 1 (%)	Category 2 (%)	Category 3 (%)
A	21	35	25
B	18	42	20
C	18	34	19
D	6	26	20

Group A – Dentistry students, Group B – Dentists with a DDS degree, Group C – Restorative dentistry specialists, Group D – Oral radiology specialists. Category 1 – ICDAS=0, Category 2 – ICDAS=1 or 2, Category 3 – ICDAS=3, 4, or 5. (ICDAS: International Caries Detection and Assessment System)

Our results are almost consistent with the results of Braga *et al*., who showed that using the cavitation threshold, radiographic interpretation has similar sensitivity to visual inspection using the ICDAS and DIAGNOdent pen. However, its performance was significantly lower at the white spot threshold in comparison with visual inspection.[16]

Since high clinical work experience plays an important role in making treatment decisions, more work and study during university time can be helpful. Holding joint training seminars between the two departments of radiology and restorative dentistry and posing numerous clinical cases can be beneficial as well.

However, according to our results, the highest rate of false-negative diagnosis was related to the student's group and the lowest belonged to the restorative dentistry specialists. This percentage indicates the missed carious teeth with the need of restorative intervention. Furthermore, the highest percentage of false-positive diagnosis was observed in the general dentists group and the least in the radiologists group. This percentage shows the amount of overtreatment performed by each group of participants. This error results in irreversible damages to tooth structure and increased costs of health care at the society level. Thus, appropriate training should be provided for target groups for the reduction of such diagnostic errors. It can be concluded that restorative dentistry specialists are less prone to missing carious cases while radiologists are less likely to recommend overtreatment.

Conclusions

According to the results of this study, interpretation of bitewing radiographs was different among the participant groups. Although not significant, the radiologists had the highest diagnostic accuracy than the other groups of participants, and the students showed the weakest performance in the diagnosis of restorative treatment needed. Furthermore, the highest percentage of decision error occurred when lesions had ICDAS 1 or 2, followed by ICDAS 3, 4, or 5, and finally 0 in all the four groups.

Acknowledgment

This research project was funded by the Research Council of Mashhad University of Medical Sciences (MUMS). The authors would like to thank the Dental Research Committee at MUMS. Furthermore, it should be noted that this paper was extracted from thesis number 2734.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Anusavice K. Clinical decision-making for coronal caries management in the permanent dentition. J Dent Educ 2001;65:1143-6.
2. Arneberg P, Hossain AN, Jokstad A. Fluoride tablet programs in healthy elderly subjects: Distribution of fluoride in saliva and plaque with tablets in different sites. Acta Odontol Scand 2005;63:65-72.
3. Lo EC, Schwarz E, Wong MC. Arresting dentine caries in Chinese preschool children. Int J Paediatr Dent 1998;8:253-60.
4. Pretty IA. Caries detection and diagnosis: Novel technologies. J Dent 2006;34:727-39.
5. Murray JJ, Majid ZA. The prevalence and progression of approximal caries in the deciduous dentition in British children. Br Dent J 1978;145:161-4.
6. Tagtekin DA, Ozyoney G, Baseren M, Ando M, Hayran O, Alpar R,

et al. Caries detection with DIAGNOdent and ultrasound. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:729-35.
7. Kamburoglu K, Kolsuz E, Murat S, Yüksel S, Ozen T. Proximal caries detection accuracy using intraoral bitewing radiography, extraoral bitewing radiography and panoramic radiography. Dentomaxillofac Radiol 2012;41:450-9.
8. Angmar-Månsson B, ten Bosch JJ. Advances in methods for diagnosing coronal caries – A review. Adv Dent Res 1993;7:70-9.
9. Gordan VV, Garvan CW, Heft MW, Fellows JL, Qvist V, Rindal DB, *et al.* Restorative treatment thresholds for interproximal primary caries based on radiographic images: Findings from The Dental PBRN. Gen Dent 2009; 57:654.
10. Medeiros VA, Seddon RP. Iatrogenic damage to approximal surfaces in contact with class II restorations. J Dent 2000;28:103-10.
11. Norman GR, Coblentz CL, Brooks LR, Babcook CJ. Expertise in visual diagnosis: A review of the literature. Acad Med 1992;67:S78-83.
12. Jensen OE, Handelman SL, Iker HP. Bitewing radiographs and dentists' treatment decisions. Oral Surg Oral Med Oral Pathol 1987;63:254-7.
13. Baghdady MT, Carnahan H, Lam EW, Woods NN. Dental and dental hygiene students' diagnostic accuracy in oral radiology: Effect of diagnostic strategy and instructional method. J Dent Educ 2014;78:1279-85.
14. Neuhaus KW, Longbottom C, Ellwood R, Lussi A. Novel lesion detection aids. Monogr Oral Sci 2009;21:52-62.
15. Kidd EA, Pitts NB. A reappraisal of the value of the bitewing radiograph in the diagnosis of posterior approximal caries. Br Dent J 1990;169:195-200.
16. Braga MM, Morais CC, Nakama RC, Leamari VM, Siqueira WL, Mendes FM, *et al. In vitro* performance of methods of approximal caries detection in primary molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:e35-41.

Author Help: Reference checking facility

The manuscript system (www.journalonweb.com) allows the authors to check and verify the accuracy and style of references. The tool checks the references with PubMed as per a predefined style. Authors are encouraged to use this facility, before submitting articles to the journal.

- The style as well as bibliographic elements should be 100% accurate, to help get the references verified from the system. Even a single spelling error or addition of issue number/month of publication will lead to an error when verifying the reference.
- Example of a correct style
  Sheahan P, O'leary G, Lee G, Fitzgibbon J. Cystic cervical metastases: Incidence and diagnosis using fine needle aspiration biopsy. Otolaryngol Head Neck Surg 2002;127:294-8.
- Only the references from journals indexed in PubMed will be checked.
- Enter each reference in new line, without a serial number.
- Add up to a maximum of 15 references at a time.
- If the reference is correct for its bibliographic elements and punctuations, it will be shown as CORRECT and a link to the correct article in PubMed will be given.
- If any of the bibliographic elements are missing, incorrect or extra (such as issue number), it will be shown as INCORRECT and link to possible articles in PubMed will be given.