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Research Paper: The Accuracy of Senior Students of Rasht Dental School in Detecting Proximal Caries in Digital Bitewing Radiographs

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ABSTRACT

Introduction: Dental caries is one of the most common chronic diseases in the world. Dentists acquire the ability to correctly identify caries through training. In addition to clinical examination, the use of radiographic techniques, especially the bitewing technique, are the main tools for the accurate detection of caries. The present study was conducted to investigate the accuracy of senior students of Rasht Dental School in detecting proximal caries.

Materials and Methods: In this cross-sectional study, ten standard-quality bitewing radiographs (152 dental surfaces) were selected. The samples were then examined for the presence and depth of interproximal caries by 39 senior students (as observers) and five faculty members as the gold standard. The findings were analyzed using statistics including sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), accuracy, and kappa.

Results: The rate of agreement (kappa) between the students and the gold standard in detecting the presence and depth of caries was 0.696 and 0.502, respectively. The students' reliability in the detection of caries and its depth yielded a kappa coefficient of 0.912 and 0.638, respectively.

Conclusion: The student's accuracy in detecting caries was significantly good. Nonetheless, they had moderate accuracy in detecting the depth of caries, and they underestimated the depth especially in the case of caries at the DEJ level. The students' reliability in detecting the presence of caries was almost excellent and their reliability for detecting the depth was significantly good, too.

1. Introduction

Dental caries is one of the most common chronic diseases in the world. It is a contagious, multifactorial, infectious, microbial disease that is caused by the complex interaction of cariogenic oral flora (biofilm) with dietary fermentable carbohydrates on the dental surface over time. At the dental level,

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carcinogenicity is characterized by localized demineralization and the loss of dental structure. One of the most desirable environments for the presence of pathogenic bacteria is the smooth surface of the enamel immediately under proximal contact. Following pits and fissures, the proximal enamel is the second most susceptible area of caries that is located immediately on the gingival side of the contact area [1]. The primary goal of any successful diagnostic and therapeutic program is the early detection of caries and limiting caries activity before a clear and progressive degradation begins. Radiography is one of the methods used for detecting caries [1, 2].

The clinical detection of proximal caries is the most difficult step and most proximal caries are not visible or sensed by touching, but can be detected in bitewing radiography [1, 2]. According to studies, bitewing radiography yields better results than ultrasound and digital fiber optic transillumination in detecting posterior interdental caries [3, 4]. One of the important issues for the differential detection of proximal caries is distinguishing cervical burnout from proximal caries. Cervical burnout is a radiolucent shadow that is commonly seen on the dental cervix. It is exactly as if part of the dental tissue is absent from the cervix to indicate a case of burnout [5].

Cervical burnout has great diagnostic significance because of its similarity to cervical and recurrent caries in radiographic views. Burnouts are often observed with increasing exposure factors that are ideal for detecting proximal caries. They are also more observed in cases where there is a contrast problem; for instance, if the tooth has a metal restoration, it may make the area above the cervical burnout completely radiopaque. In addition, since this area is the main site for the recurrence of caries, detection becomes more difficult [5].

When there is a perfectly clear density difference, like between the enamel and dentin, a more radiolucent area may appear in the immediate vicinity of the enamel. This optical illusion is called a Mach band and can lead to some false positive interpretations. Other cases that may be mistaken for proximal caries include various dental anomalies, like hypoplastic cavities. The detection of caries, therefore, needs clinical examinations in addition to radiographic examination [5].

The correct detection of caries can prevent its spread, and the lack of proper detection can lead to its continuation even under restoration. One of the important issues that graduate students of dentistry should be fully aware of is the ability to correctly detect caries. Studies show that about 50% of differences of opinion between dentists in caries detection is related to determining the depth of the caries [6]. Given the limited studies on this subject, conducting detailed studies to examine students' accuracy in the radiographic detection of caries is essential and can lead to positive results and help identify the strengths and weaknesses of the students. Given the lack of similar research at Rasht Dental School, this study investigated the accuracy of senior students of Rasht Dental School in detecting the presence and depth of caries in bitewing radiographs to help improve the quality of the training provided to the students.

2. Materials and Methods

This cross-sectional study was conducted in 2016 to examine the accuracy of the detection of proximal caries by using bitewing radiographs in 39 senior dentistry students of the Guilan University of Medical Sciences in Rasht City, Iran. Ten digital standard-quality bitewing radiographs (including 152 proximal surfaces) were selected (CI 95% of agreement) from patients' records in a private radiology clinic [7]. First, informed consent was obtained from all students. This study was registered with the code of ethics of IR.GUMS.REC1395.298.

* The inclusion criteria were: Radiographs with a standard quality; The interproximal surfaces of the posterior teeth be completely visible in the radiographs; No overlap between the interproximal surfaces in the radiographic views; The selected radiographs containing the first and second premolars and the first and second molars; The participants being senior students of dentistry at Rasht Dental School, and The participants consenting to participation in the study.

The bitewing radiographs were prepared using an intraoral radiography device (Acteon, X-MIND, Italy) with the exposure conditions of mA=7 and Kvp=65, exposure time=0.32 with Photostimulable Phosphor (PSP) plate technology (a digital intraoral sensor) and the digitizer DIGORA Optime in Scanora 5.1.2 software with similar density and contrast. The teeth had no proximal filling or recurrent caries. Overall, the present study examined only proximal surface caries (mesial-distal) limited to the crown of the teeth. The studied surfaces included 152 mesial and distal surfaces. In each jaw, if the distal surface of the canine was visible in the radiograph and the mesial and distal surfaces of the premolars, the first and second molars and also the third molar (if any) were independently examined by 39 senior students on a common negatoscope in a semi-dark visual environment. The information obtained was recorded in a checklist that monitored the presence, absence, and depth of the

caries. The depth of the caries was determined in the checklist according to the following classification: A. Caries at the enamel level; B. Caries at the DEJ level; C. Caries at the dentin level

Each student was given a code after completing the checklist. To obtain intra-observer reliability between the students' detections, 11 of the same 39 students were randomly selected to examine the same bitewing radiographs under the same conditions after one week, and a new checklist was registered with their previous codes.

Three oral and maxillofacial radiology specialists and two restorative specialists from the faculty were selected as the gold standard for the detection of caries in the same radiographs. The majority's view about the presence or absence of caries and its depth was taken as the gold standard (the view shared by at least three of the faculty members). If no majority could be achieved, the higher depth was taken as the gold standard. The faculty members observed the bitewing radiographs with the same negatoscope in a semi-dark room and marked the corresponding checklist.

To calculate the detection accuracy for the presence or absence of caries and its depth, each student's detection was assessed according to the majority view of the faculty members about the presence or absence of caries and its depth. If the student's detection matched the majority view of the faculty members, that student was given one point; otherwise, they received zero per each level in the bitewing radiographs.

After collecting the data, SPSS-21 was used to determine the students' detection sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and accuracy. Kappa agreement coefficient was used to determine the rate of agreement between the students and the gold standard in detecting the presence and depth of caries and to determine the students' reliability in detecting caries and their depth.

3. Results

This study examined the accuracy of 39 senior students of Rasht Dental School in detecting the presence and depth of proximal caries in bitewing radiographs. To examine the students' detection accuracy, the judgment of a group of five experienced faculty members was taken as the gold standard. To investigate the reliability of the students' detection, 11 students participated in a second assessment after a week.

According to Table 1, the rate of agreement between the students' and the faculty members' views about the presence of caries was statistically significant (P<0.0001, Kappa=0.696±0.01) and represented a significant theoretical agreement. Sensitivity was 81.1%, specificity 88.7%, PPV 79.9%, and NPV 89.5%. These results generally indicate that the students' accuracy in the detection of caries was 86%. The high PPV and NPV of detection show that the students have generally been successful in detecting the presence or absence of caries.

The rate of agreement between the students' and the faculty members' views about the depth of caries was statistically significant (P<0.0001, kappa=0.502±0.009) and represented a moderate agreement. The students' accuracy in detecting the depth of caries was 73.4%. It can be concluded that the students were weaker in detecting the depth of caries than detecting its presence or absence. To obtain the detection sensitivity, specificity, PPV and NPV of caries' depth, the views of the faculty members and the students were separately examined about each depth (enamel, DEJ, and dentin).

Table 2 presents a more detailed examination and comparison of the students' ability to detect the depth of caries. Table 2 indicates that the students have shown the best performance in detecting caries' depth at the dentin level and their performance was poorest in detecting caries' depth at the DEJ level. The false positive and negative diagnostic values confirm this finding. To determine the students' reliability in caries detection, the rate of agreement after one week was P<0.0001 with a kappa coefficient of 0.912±0.011, which indicates an almost perfect agreement. To determine the students' reliability in the detection of caries depth, the rate of agreement after one week was P<0.0001 with a kappa coefficient of 0.638±0.015, which indicates a significant rate of agreement.

4. Discussion

The early detection of caries can limit their development and eliminate the need for complex restorative treatments. In addition, a proper treatment can be planned if the caries' depth is detected correctly [7, 8]. The choice of the best method for detecting and observing caries has always been the subject of extensive research. The most convenient and common method for the detection of proximal caries is clinical examination and bitewing radiography [9, 10]. According to the results, the rate of agreement between the students' and the faculty members' views about the presence of caries was statistically significant (P<0.0001, kappa=0.696±0.01)

Table 1. Assessing the rate of agreement between the students' views and the gold standard about the presence of caries

			The Faculty Members' View About the Presence of Caries (Gold Standard)		Total	Coefficient of Agreement
			No	Yes		
The students' view about the presence of caries	No	Number	3392	398	3790	Kappa±Standard Error=0.696±0.01 P<0.0001
		Percent	57.2	6.7	63.9	
	Yes	Number	430	1708	2138	
		Percent	7.3	28.8	36.1	
Total		Number	3822	2106	5928	
		Percent	64.5	35.5	100.0	
Diagnostic index			NPV=89.5%; PPV=79.9%; Spec.=88.7%; Sen.=81.1%; Accuracy=86%			

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and indicated a significant theoretical agreement. The students' detection sensitivity for caries was 81.1%, their specificity 88.7%, PPV 79.9%, NPV 89.5%, and accuracy 86%. These results suggest that senior dentistry students at the University of Guilan were more successful in identifying healthy teeth and have been more inclined to consider suspicious images as 'no caries.' In a study by Mileman et al., 105 proximal dental surfaces were evaluated by two groups, including dentistry students and general dentists in the Netherlands.

The detection sensitivity was 67.2% in the dentistry students and 54% in the general dentists. This disparity of results might be related to the duration of training at school (six vs. four years) apart from educational differences and different individual capacities. The analysis of the data also shows that in the study in the Netherlands, the students had more real and false positive detections than the general dentists; in other words, contrary to the present study, they were more inclined to detect suspicious images as 'caries' [11].

In a study by Romoozi et al., ten panoramic radiographs were examined by 30 senior students and two faculty members as the gold standard. The rate of agreement between the faculty members and the students about the presence or absence of caries had a kappa coefficient of 0.428, which is at a moderate level and statistically significant. In their study, detection sensitivity was 47%, specificity 91.9%, PPV 63%, and NPV 85.3% [12]. These results are somehow consistent with the present findings. Nonetheless, the low level of caries detection sensitivity in that study might be due to the limitations of panoramic radiography. Panoramic radiographs cannot function as well as bitewing radiographs in showing proximal caries [13]. Moreover, panoramic images have overlaps at the premolars and the accurate observation of the interdental surfaces of premolars, and therefore the correct detection of caries in these areas becomes impossible [14]. The results obtained by Falahzadeh et al. at Qazvin University, Kamburoglu et al. at Ankara University, and Abdinian et al. at Isfahan University showed that bitewing radiography has a higher diagnostic value than other radiographic techniques in proximal caries detection [9, 15, 16]. The results of the mentioned studies on the estimation of caries depth by students show that they have been more successful in determining the depth

Table 2. Comparison of the students' detection of caries' depth in each level (dentine, enamel, and DEJ)

	Enamel (%)	DEJ (%)	Dentin (%)
Sensitivity	47.8	22.48	65.13
Specificity	87.6	94.98	94.13
Positive predictive value	49.74	29.53	43.87
Negative predictive value	86.76	92.9	97.45
False positives	50.3	70.5	56.1
False negatives	13.2	7.1	2.5

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of caries at the dentin level, which is consistent with the present findings.

In a study by Shirani et al., in which the sectional pathology of teeth was the gold standard, senior students examined bitewing radiographs, and their sensitivity of caries detection was 62.2% overall and 55.06% for caries limited to the enamel and 69.6% for caries limited to the dentin [17]. Comparing the results of that study with the present study shows that both groups performed similarly in detecting caries at the dentin level. The differences in the detection sensitivity between these two studies can be due to the differences in their gold standards (a cross-sectional incision in that study and faculty members' views in the present study).

Hekmatian et al. noted that the rate of agreement between the students and the faculty members about the presence of caries had a kappa coefficient of 0.22, which indicates a weak agreement. The sensitivity and specificity were 23.4% and 96.9%, respectively. The findings of the cited study suggest that the students have been able to correctly detect only a few cases of interdental caries by the bitewing radiographs. A possible cause of this weakness could be the low quality of training, the high number of students in the department, the inappropriate student to professor ratio, the students' lack of talent in this field, the intensive and periodic training and the students' low experience [18]. The cited study shows less desirable results compared to the present findings, especially with regard to diagnostic sensitivity and the rate of agreement between the students and the faculty members about the presence of caries.

In a study by Nikneshan et al., bitewing radiographs were examined by 30 senior students and five faculty members as the gold standard. The students' detection sensitivity was 78.22%, specificity 82.14%, PPV 79.68%, and NPV 80.81%. The diagnostic accuracy of these students was 43.4% for the depth of caries limited to the enamel and 29.8% for depth of advanced caries at the dentin level [7]. These results indicate that the students' diagnostic ability to distinguish between cases of caries and no caries was desirable, which is consistent with the present findings. The results of the students' detection of caries' depth showed that the students identified surface caries better than deep caries and enamel caries better than dentin caries. However, detailed studies suggest that the students underestimate caries depth in most cases, which, in addition to an actual deficiency in diagnostic skills, might be somewhat related to their conservatism and the avoidance of more complex cases. In the present study, the students detected advanced caries at the dentin level better than surface (enamel) caries.

In a study by Espelid et al. on the diagnostic accuracy of proximal caries from bitewing radiographs, the views of seven dentists about these radiographs were compared with the gold standard, and the results showed that diagnostic variability increased between the seven dentists as caries penetrated deeper into the lower layers. The difference between them and the observer group also increased in the same manner. Another finding was that dentists have a higher consensus on the detection of surface caries, which is different from the present findings. The gold standard was the histological sections of the teeth in the cited study, which differs from the method used in the present study [19].

Diniz et al. showed that the repeatability of occlusal caries detection through radiographic examinations is affected by the clinical experience of the observers and their trainings. Significant differences have also been observed between senior students and dentists with five to seven years of clinical work experience in caries detection sensitivity [20]. In a study by Yasar et al. at Selcuk College in 2011, senior students had a greater agreement in caries detection through bitewing radiographs than fourth-year students [21]. In line with the results of these studies, the study by Halme et al. on four groups, including senior dentistry students, third-semester dentistry students who had passed a course in oral radiology, senior students of oral health and dentists with at least five years of experience, showed that training, awareness, and experience have a direct impact on the detection of dental caries spread into the dentin [22].

In a study by Wenzel et al., the diagnostic accuracy of caries detection software was compared with that of human observers and it was found that the software has less accuracy in determining proximal caries compared to human observers [23]. In general, the results of these studies emphasize the need for more proper and adequate training of students for accurately detecting proximal caries through bitewing radiographs. Nevertheless, in a study by Wrbas et al., no significant differences were observed between the students who had undergone additional training and the rest of the students in the ability to detect proximal caries, and there were differences between them only in very special cases [24]. The results of a study by Shams et al. showed that despite the role of education in enhancing the ability to detect caries, training alone cannot increase this ability to a satisfactory level [25].

In one study by Maupome et al., five bitewing radiographs were shown to senior dentistry students to ex-

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amine their ability to determine proximal caries through the radiographs. The data obtained were compared and analyzed against the gold standard, which included the views of two faculty members. The results showed that false caries detection was common [26]. The reason for this weakness could be the poor training at school, the students' dearth of theoretical knowledge, or their lack of experience. Assessing the students' reliability in detecting the presence of caries in the cited study yielded an agreement coefficient of 0.664 after one month, indicating a desirable agreement rate. In the present study, assessing the students' reliability in detecting the presence of caries yielded an agreement coefficient of 0.912 after one week, indicating a perfect agreement coefficient. The difference in the students' reliability in these two studies might be due to the differences in the intervals between examination and re-examination. An important point in this study is the use of digital bitewing radiographs, which definitely have a much better image quality than analog images, and this superiority can influence the detection accuracy of caries and its depth.

Analyzing the students' detection sensitivity and specificity, PPV, NPV, false positives, and false negatives for caries depth showed that the students were more successful in determining the depth of dentinal caries, while their weakest detection was observed in DEJ caries. This weakness could be due to the students' poor diagnostic skills and little experience in caries detection and the presence of anatomical artifacts (i.e., the Mach band effect) in radiographic images. These artifacts make the students recognize only a few cases of enamel and DEJ caries that can be restored by conservative measures through radiographs, and since radiography provides the main tool for detecting these types of caries, the likelihood of not detecting these caries by the students is high.

5. Conclusion

The accuracy of the senior students of Rasht Dental School in detecting the presence of caries was significantly good, but the accuracy of their detection of caries depth was moderate, and underestimation was particularly prevalent in the detection of caries at the DEJ depth. The students' reliability was also almost excellent in detecting caries and significantly good in detecting the caries' depth.

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Conflict of Interest

The authors declared no conflicts of interest.

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