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Correlation between visual and radiographic examinations of non-cavitated occlusal caries lesions – an *in vivo* study

Correlação entre os exames visual e radiográfico de lesões de cárie oclusal não cavitadas – estudo in vivo

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ABSTRACT: The aim of this study was to conduct an *in vivo* investigation of the correlation between the visual and radiographic scoring systems by Ekstrand *et al.*[7] (1997) for the diagnosis of occlusal caries lesions. The study sample comprised 147 occlusal sites from 23 patients. Two trained and experienced examiners performed the clinical visual examinations. A third examiner, which was also trained, experienced and blind to the results of the visual clinical examination, performed the analysis of the bitewing radiographs. The correlation between visual and radiographic scores was assessed by Goodman & Kruskal's gamma correlation coefficient. Results showed a strong correlation between the scores for occlusal caries found in the visual and radiographic diagnosis systems used in this study.

DESCRIPTORS: Dental caries; Dental occlusion; Radiography, bitewing.

RESUMO: O presente estudo verificou *in vivo* a correlação existente entre os sistemas de escore visual e radiográfico de Ekstrand *et al.*[7] (1997) para diagnóstico de lesões de cárie oclusal. A amostra do estudo foi constituída de 147 sítios oclusais obtidos a partir de 23 pacientes. Os exames clínicos visuais foram realizados por dois examinadores treinados e calibrados. A análise das radiografias interproximais foi realizada por um terceiro examinador também treinado e calibrado, que desconhecia os resultados do exame clínico visual. A correlação entre os escores visual e radiográfico foi avaliada por meio do coeficiente de correlação gamma de Goodman & Kruskal. Os resultados revelaram uma forte correlação existente entre os escores dos sistemas de diagnóstico visual e radiográfico de cárie oclusal adotados no presente estudo.

DESCRITORES: Cárie dentária; Oclusão dentária; Radiografia interproximal.

INTRODUCTION

Due to the growing interest in the effect of preventive and non-preventive measures and to the large variation in the clinical and radiographic thresholds used, studies have been proposed to assess the methods traditionally used for the diagnosis of caries lesions in the occlusal surface [6,8,9,11,15,17].

The clinical and radiographic record of occlusal caries lesions requires a diagnostic system that reflects the dynamic nature of the caries disease in all its stages of progression, so that the different lesion stages can be more accurately identified, with special attention to the improvement of the visual method. According to Machiulskiene *et al.*[12] (1999), when clinically non-cavitated caries are not taken into account in clinical examination, bitewing radiographs may be used as additional information to detect these lesions[13]; if non-cavitated caries lesions are included during the clinical examination, the additional information provided by bitewing radiographs may be questionable. These observations indicate that the clinical criteria used in diagnosis are critical and that they determine the value of the additional information obtained by the bitewing radiographic examination. According to Gray, Paterson[10] (1997), cavitated lesions are easily diagnosed by clinical examination. However, diagnosis of subsurface enamel lesions, especially diagnosis of those lesions where a seemingly healthy enamel surface covers extensive progression into the dentin, is more complex, therefore requiring a more thorough analysis of the characteristics related to opacity, coloration and texture during clinical examination[14,16].

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Ekstrand *et al.*[4] (1995) used histological validation to determine the stages of occlusal caries lesions. This validation correlated the many visual and radiographic stages of caries lesions with the degree of enamel and dentin demineralization. The study established that progressive signs of outer mineral destruction, as well as histological reactions, can be arranged in linear scales, from early mineral loss up to total tissue destruction. The authors described that, so far, despite the fact that many researchers have conducted studies on occlusal caries diagnosis, no attempt had been made to systematically examine the relationship between clinical and histological changes in the many stages of progression of caries lesions. The study was performed *in vitro* using 140 extracted third molars. The authors examined the central fossa with a stereoscopic magnifying glass (16 X) and performed the visual examination after standardized prophylaxis and drying procedures had been carried out. Caries signs were classified using a score system ranging from healthy enamel to cavitation.

In a laboratory study carried out in 1997, Ekstrand *et al.*[7] (1997) investigated 100 occlusal surfaces for the reproducibility and accuracy of three diagnosis methods used to determine the depth of demineralization on the occlusal surface[6]. In the present study, the authors criticized the visual and radiographic criteria previously used in the study by Ekstrand *et al.*[4] (1995) for considering the use of these scores difficult in routine clinical practice due to the large number of scores and presented a new, more simplified scoring system for visual and radiographic examination. Results show that the teeth that were assigned visual scores of healthy showed signs of health in histology. Additionally, they showed that radiographs are an excellent method to detect softened and infected dentin, mainly in the middle or inner thirds of the dentin, but it presents diagnostic failures in the outer third of the dentin and in enamel.

It is important to consider that visual examination is always the first clinical step in any type of currently available technology used as adjuvant in the diagnosis of occlusal caries lesions, such as, for example, DIAGNOdent® (KaVo DIAGNOdent KaVo, Biberach, Germany) , the electrical resistance test and FOTI[3,7] (Schott Fibre Optics, Doncaster, UK). For this reason, for the diagnosis and treatment decisions of clinical situations where the occlusal surface enamel is non-cavitated, but where dentin is already involved, the importance of studies aimed at a better *in vivo* understanding of the relationship between visual clinical examination and bitewing radiographic examination is further stressed.

The goal of this study was to check the correlation between 0, 1, 2, 3 and 4 scores of the visual and radiographic scoring system by Ekstrand *et al.*[7] (1997) for the *in vivo* diagnosis of occlusal caries lesions.

MATERIALS AND METHOD

Sample

The study sample comprised 147 occlusal sites from 23 patients referred for treatment at the program of Cariology, School of Dentistry, ULBRA (Lutheran University of Brazil). In order to be included in the study, patients had to be older than 12, have at least one permanent molar and/or premolar that met the inclusion criteria of the sites in the sample and agree to participate in the study by signing a consent form. Additionally, the teeth of the selected patients should meet the following criteria: be fully erupted and present no restoration on the occlusal surface and free surfaces. The mean age of the patients was 15.94 ± 1.41 years, and eleven were male and twelve female. All patients had clinically visible caries activity shown by the presence of active white spots.

Assessment parameters

Visual clinical examination

Two trained and experienced examiners performed the clinical examinations according to the visual examination criteria established by Ekstrand *et al.*[7] (1997) (Table 1). The score for each site was determined after making the assessment at two different times: with a wet occlusal surface, but without the presence of saliva and with a dry occlusal surface. The training of the examiners for the application of the scores used in the visual clinical examination was made by visual clinical examination in four patients and the discussion of the respective scores. The intraexaminer agreement showed a kappa coefficient of 0.82 for examiner 1 from two assessments with a 7-day interval between them made in 182 sites and a kappa of 0.70 for examiner 2 from 138 sites. Prior to the visual clinical examinations, dental plaque was removed from the occlusal surfaces with a prophylactic paste (Vigodent, Rio de Janeiro, Brazil) and Robinson brush (KG Sorensen, Barueri, SP,

TABLE 1 - Visual clinical examination according to Ekstrand *et al.*[7] (1997).

Score	Criteria
0	No or slight change in enamel translucency after prolonged air-drying (5 seconds).
1	Opacity or discoloration hardly visible without drying, but visible after air-drying.
2	Opacity or discoloration visible even without air-drying.
3	Localized enamel breakdown in opaque or discolored enamel and/or grayish discoloration from the underlying dentin.
4	Cavitation in opaque or discolored enamel exposing the dentin.

TABLE 2 - Radiographic examination according to Ekstrand *et al.*[7] (1997).

Score	Criteria
0	No visible radiolucency.
1	Radiolucency in the enamel.
2	Radiolucency in the dentin, involving the surface or outer third of the dentin.
3	Radiolucency in the dentin, involving the middle third of the dentin.
4	Radiolucency in the dentin, involving the inner third of the dentin.

TABLE 3 - Correlation between observations made by examiner 1 (visual) and examiner 3 (radiographic) according to the Ekstrand *et al.*[7] (1997) scores in 147 occlusal sites.

Examiner 1 (visual scores)	Examiner 3 (radiographic scores)				
	0	1	2	3	4
0	25	1	1		
1	28	1	4	1	
2	23		7	1	
3	20		25	7	
4				1	2

Gamma = 0.70; $p < 0.001$.

TABLE 4 - Correlation between observations made by examiner 2 (visual) and examiner 3 (radiographic) according to the Ekstrand *et al.*[7] (1997) scores in 147 occlusal sites.

Examiner 2 (visual scores)	Examiner 3 (radiographic scores)				
	0	1	2	3	4
0	24	1	1		
1	25	1	2	1	
2	30		12	2	
3	17		22	6	
4					2

Gamma = 0.70; $p < 0.001$.

Brazil). It should be pointed out that considering the fact that the visual score 3 enables more than one approach, only the presence of grayish color in the underlying dentin was taken into account in the study, avoiding the inclusion of visual characteristics indicative of microcavities (localized breakdown on opaque or discolored enamel).

Radiographic examination

A third examiner performed the analysis of the bitewing radiographs using the criteria set down by Ekstrand *et al.*[7] (1997) (Table 2). The third examiner was also trained and experienced and was blind to the results of the visual clinical examination. The result of the intraexaminer kappa agreement coefficient in relation to the radiographic examination in 92 sites was 0.95. The radiographic technique used was the bitewing performed with the help of an intraoral positioner. The kilovoltage of the X-ray equipment from Spectro II® (Dabi Atlante, São Paulo, Brazil) was 60 kVp, 10 mA, with an exposure time of 0.8 second, using Ektaspeed (Eastman Kodak, New York, USA) radiographic film developed by the time/temperature method.

Data

The correlation between visual and radiographic scores was assessed by the gamma correlation coefficient by Goodman & Kruskal. The significance level used in all analyses was $p \leq 0.05$, with data being analyzed and processed with the help of the programs SPSS® version 11 (SPSS Inc., Chicago, Ill, USA) and Sigma Plot™ version 2.10 (GmbH Softer-ware, Münshen, Germany).

RESULTS

Tables 3 and 4 present the correlation between the results from the visual clinical examination performed in 147 sites by examiners 1 and

2 respectively, and the radiographic examination performed by examiner 3. In Table 3, the results of the observations showed a gamma correlation coefficient = 0.70, thus showing, according to Hopkins[11] (2002) and Everitt[9] (1992), a strong correlation between the scores of the visual examination performed by examiner 1 and the scores from the radiographic examination. Likewise, from the results shown in Table 4, it can be seen that the gamma correlation coefficient between the scores from the visual clinical examination performed by examiner 2 and the radiographic scores by examiner 3 was 0.70. This means that identification of occlusal caries lesions according to the visual scores used in this study led to a 70% reduction of errors in the prediction from the radiographic score.

DISCUSSION

Checking the correlation between all visual and radiographic clinical scores in 147 sites, a strong correlation between visual and radiographic examination (gamma = 0.70) was found in this study. Considering that correlation means the relationship in both directions, because it describes the association between two variables without making any judgement whether one is the cause or consequence of the other, a trend of change was found in the set of visual and radiographic scores as the value of both increased from 0 to 4.

Cordeiro, Campos[2] (2002) compared different methods to diagnose occlusal caries in permanent teeth and found that the clinical examination combined with radiographic examination is the most widely used method by practitioners. According to the authors, the scores by Ekstrand *et al.*[7] (1997) reproduce the clinical situations found in the daily routine of the dental surgeon because they are based on signs found on the enamel surface such as opacities, white spots, brown spots, presence of cavities or microcavities and the combination of these conditions.

The studies by Ekstrand *et al.*[4,5,7,8] (1995, 1998a, 1997, 1998b) used a histological classification that combines an area of deep enamel demineralization with an area of early dentin demineralization based on the premise that the early dentin demineralization area remains restricted to the contact area between the enamel lesion and the dentin enamel junction, with no lateral spread along this interface[1,4,6,7]. This characteristic is a significant differentiating factor in the histological assessment, and is critical for the assignment of visual and radiographic scores, and taking into account that changes in dentin during the progression of the caries lesion cannot be understood without considering the spread of the lesion on enamel[17].

An important piece of information concerning visual scores established by Ekstrand *et al.*[4] (1995) regards the characteristics of the visual clinical score 4 (discoloration of enamel in brown shades with or without localized destruction on the surface). It was later adapted in Ekstrand *et al.*[7] (1997) for the visual clinical score 3 (characterized by localized enamel breakdown in opaque or discolored enamel and/or grayish discoloration from the underlying dentin). The characteristics of these scores presented difficulties related to the detection of small areas of destruction located at spots of brown discoloration. The authors have suggested that diagnostic and treatment decisions on surfaces that present these characteristics are probably more difficult to make, and this was one of the questions raised by the present study.

The radiographic examination has shown greater diagnostic sensitivity when combined with the clinical examination, thus suggesting that the use of radiographs is particularly important when visual findings give rise to doubt[12].

Machiulskiene *et al.*[12] (1999) have shown that the efficacy of bitewing radiographs depends on the refinement of the clinical diagnostic criteria and that, unlike clinical examination, radiolucency present in the radiograph does not provide enough information on the status of the lesion activity and, therefore, should not be used in isolation to decide the type of treatment to be used. According to the authors, there are two main arguments for the use of bitewing radiographs as an adjuvant in the diagnosis of occlusal and proximal caries: radiographs are important to detect caries lesions that remain undetected by clinical examination and if the depth of the lesions can be assessed, it enables a correlation between their severity and treatment choices.

An important consideration is that in this study no hidden caries lesion were found, which are those caries characterized as seemingly clinically healthy and that are diagnosed by radiography. This finding is in agreement with the studies of Ekstrand *et al.*[7] (1997), Machiulskiene *et al.*[12] (1999). These studies found that the prevalence of hidden caries depends on the diagnostic criteria used and the way the visual clinical examination is performed, and that instead of being a result of the sample, prevalence could be correlated to the use of inadequate visual clinical criteria.

CONCLUSION

The analysis of the results showed a strong correlation between the scores of visual and radiographic diagnostic systems of occlusal caries used in this study.

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