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SHORT COMMUNICATION

Clinical cavitation and radiographic lesion depth in proximal surfaces in an Indian population

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Abstract

Objectives. To assess the relationship between clinical cavitation and radiographic caries lesion depth in proximal surfaces of permanent posterior teeth in an Indian population. This study also assessed the clinical feasibility of applying 'western guidelines' to this population from the developing world. ***Materials and methods.*** Relationship between clinical cavitation and radiographic caries lesion depth in proximal surfaces in an Indian population was assessed. Proximal surfaces ($n = 126$) without restorations were examined on bitewing radiographs in patients with suspected caries and lesion depth was recorded by five observers. The radiographic scoring scale was 0 = sound; 1 = lesion in enamel; 2 = lesion in outer 1/3 of dentine and 3 = lesion in inner 2/3 of dentine. Orthodontic separators were placed interdentally and removed after 3 days, where surfaces were recorded as cavitated (yes/no) by two clinical validators (gold standard). ***Results.*** Enamel lesions were cavitated in 25.6–38.3%, outer dentinal lesions were cavitated in 83.3–100% and inner dentinal lesions were cavitated in 96.4–100% depending on observer and validator. On applying 'western guidelines' for treatment decision to the radiographic findings of lesion depth, 80–100% of the lesions observed in outer dentine would lead to a false (non-operative) treatment decision. ***Conclusions.*** Radiographic shallow carious lesions were often cavitated in this population. The threshold for cavitation in this study population is suggested to be set between enamel and outer dentine in contrast to western guidelines.

Key Words: *radiography, bitewing, diagnosis, dental caries, cavitation*

Introduction

Proximal surfaces of the posterior teeth are probably the most inaccesible part of the teeth to examine clinically. Clinical visual–tactile examination is, therefore, often aided by bitewing radiography to assess the depth of a caries lesion. The bitewing radiograph aids in identifying demineralization of the hard tissues [1], but a single radiograph cannot display whether the demineralization is a sign of an active or arrested caries lesion, neither is the radiograph able to distinguish between cavitated lesions and lesions with an intact surface [2]. In spite of these drawbacks, bitewing radiography still remains the 'standard of care' radiograph for proximal surface caries management. An incomplete clinical examination and a bitewing giving deceiving information on the cavitation nature of the proximal surfaces could have an undesired impact on the treatment protocol [3].

In recent years, the treatment strategy has been to spare operative treatment for cavitated proximal surfaces [4]. For choice of treatment it is, thus, vital that surface cavitation be identified. Even though the bitewing radiograph is not accurate in predicting cavitation, there may be a logical relationship between radiographic lesion depth and surface break-down. Early studies attempted to assess this relationship, mainly for western populations [5–9], with only two studies from developing countries, Brazil and Saudi Arabia [10,11]. For these western populations the risk of cavitation in surfaces with a shallow radiographic lesion was found to be low [7,12] and the general treatment guidelines are, thus, that lesion depth less than or equal to the outer third of the dentin should

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not be subject to operative treatment [13,14]. However, these guidelines have been scarcely validated for other populations, particularly from developing countries, where the caries activity, access to a dental healthcare and availability of fluorides may be quite different from that of industrialized countries. It has also been suggested that new studies are needed to validate these guidelines [14]. For comparative analysis these guidelines will be referred to as 'western guidelines' in this article.

This study assessed primarily the relationship between clinical cavitation and radiographic caries lesion depth in proximal surfaces of permanent posterior teeth in an Indian population. Further, the study also assessed the clinical feasibility of applying the 'western guidelines' to this population from the developing world.

Materials and methods

This study includes partly data originating from an earlier study [15] and partly new surfaces. Ethical committee approval was obtained as an extension to the previous study with the required modifications (Approval number: 012/EC/2012).

A total of 51 subjects participated in the study, contributing 126 proximal surfaces. Twenty male and 31 female patients with age ranging from 18–63 years (mean = 36.0 years) were included. The group was, thus, heterogeneous with respect to age and the years after tooth eruption, therefore, vary considerably. Initially, patients who were suspected to have carious lesions at two adjacent surfaces after a visual clinical examination (discolorations observed) and who then required a bitewing examination for their treatment, were invited to participate in the study. Exclusion criteria were restorations in the teeth to be examined (restorations in adjacent teeth were allowed) and surfaces with large cavitation or gross lesions easily observed during clinical examination. The study cohort could be described as belonging to lower-to-middle socio-economic class with high caries activity, who are aware of treatment needs and have access to oral healthcare, but no access to fluorides, neither in the form of drinking water nor toothpaste.

Two-by-two adjacent surfaces in the upper and/or lower permanent premolar/premolar, premolar/molar and molar/molar interfaces were included. Twelve patients contributed with two pairs of surfaces. Bitewing radiography was performed on the same day of the initial clinical examination. Patients were thereafter subjected to wear an orthodontic elastic separator (American Orthodontics Corp., Sheboygan, WI) placed between the two suspected surfaces in question. The 12 patients who contributed with two pairs of surfaces wore two separators. These were not in the same side of the mouth.

Bitewing radiographs were recorded on size 2 film (Ektaspeed Plus, Eastman Kodak, Rochester, NY) using an interproximal device holder (Bluedent India, Ullagaram, Chennai, India). The exposed films were processed in an automatic processing machine at 27°C with a 4.5 min processing cycle. Bitewings displaying both proximal surfaces to be sound or with large carious lesion in both proximal surfaces were rejected at this stage. Radiographers who were not part of the study performed the bitewing examinations.

Five radiographic observers with 5–25 years of experience in reading bitewing images scored the images. All observations were done in a quiet windowless room with dim lighting. Observers were allowed to use 2-fold magnification with a constant light intensity. The following scoring scale was used for the radiographic assessment (Figure 1): 0 = sound; 1 = lesion restricted to the enamel (enamel lesion); 2 = lesion into dentine, less than or equal to one third of the dentine (outer dentine lesion); 3 = lesion more than one third into dentine (inner dentine lesion).

The 'gold standard' was clinical examination after tooth separation, which was performed separately by two clinical validators not involved in the radiographic scoring. After 3 days, the tooth separator was removed leaving an interproximal space of ~0.5 mm. Patients, who had dislodged or broken the separator, were excluded from the study (n = 4, all from patients contributing only two surfaces). This left 126 surfaces, which finalized the study. The interproximal space was cleaned with Superfloss (Oral B laboratories, Okhla Industrial Estate, New Delhi, India), washed and dried. The visual examination was recorded under relative saliva isolation (with a cotton roll) and with the aid of a blunt explorer probe and a flat dental mirror. The probe was used for tactile evaluation of the surface without pressure. The two clinical validators scored the surfaces as cavitated (yes/no) immediately after one-another, one blinded to the other's scorings. Cavitation was defined as present

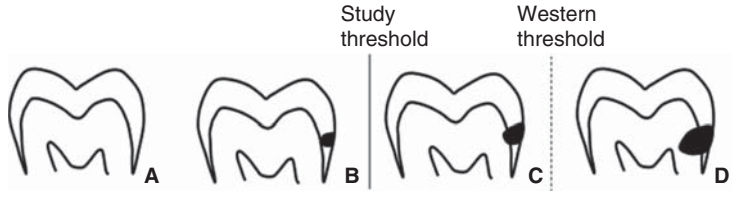

Figure 1. Operative threshold offered between stages C and D following 'western guidelines' and stages B and C in the study population.

when there was a definite break in the continuity of enamel. Any concavity or depression/wear on the proximal surface was not considered a cavity.

Data analysis

Statistical analysis was performed after transferring all the data to Microsoft Excel 2003 software (Microsoft Corporation, Richmond, WA, USA). Stata version 12.1 was used for analysis. Inter-observer agreement for the two clinical validators was expressed by kappa statistics. For each of the five observers the radiographic scores were compared to the clinical validation of the surface (cavitated/intact) performed by each clinical validator. The findings were held against 'western guidelines' for treatment decision and true and false positive and negative decisions regarding treatment according to these guidelines were calculated.

Results

There was substantial agreement between the two clinical validators' assessment of cavitated/non-cavitated surfaces since only 10% of the surfaces were not scored identically by the validators. Validator 1 found 77 cavitated surfaces while validator 2 found 82 (Table I). The kappa value was 0.8.

A larger variation was seen between radiographic lesion depth scores among the five observers (Table I). The percentages of sound scores for the five observers ranged between 10.3–19.8%, while the percentage of scores in enamel ranged between 30.9–37.3%. Between 23–35.7% of scores were outer dentine lesions, while the most homogeneous scores were inner dentine lesions (range = 19.8–23%).

For the five radiographic observers, lesions recorded as sound were cavitated in 7.1–32%, lesions recorded in enamel were cavitated in 25.6–38.3%, lesions recorded in outer dentine were cavitated in 83.3–100% and lesions recorded in inner dentine were cavitated in 96.4–100% of the cases. For two/three of the radiographic observers, there was a 100% concordance between their score of a lesion in outer dentine and cavitation of the surface (depending on validator 1 or 2). For the other two/three radiographic observers, there was 83.3–96.7% concordance between their score in outer dentine and cavitation. For almost all radiographic observers' scores in inner dentine, there was a 100% concordance with cavitation, only for one observer (with validator 1), one score in inner dentine was not related to a cavitated surface (Table I).

Applying 'western guidelines' for treatment decision to the radiographic findings of lesion depth, between 80–100% of the lesions observed in outer dentine would lead to a false (non-operative) treatment decision, i.e. those lesions, which were in fact cavitated, but would be left untreated if following the guidelines.

Discussion

Studies have both supported [16] and questioned [17] the use of the tooth separation method as a validation of other diagnostic methods. Including two clinical validators in this study made it possible to assess the variation also for the 'gold standard' method. In an earlier study [12], the variation in scoring cavitated/non-cavitated surfaces with radiographic enamel lesions ranged from 4–8% and, with radiographic dentinal lesions, the variation ranged from 20–44% at various recall examinations. It has also been observed that more conservative observers yielded 100% clinical cavitation, while more aggressive observers reduced this number marginally. This, therefore, highlights the relation between sensitivity and specificity in diagnostic science, particularly caries diagnosis. In the present study there was overall a good agreement between the two clinical validators for cavitated and intact surfaces, with a kappa value of 0.8.

In this study one proximal surface may not be independent of the other as a carious lesion on one may influence caries activity on the adjacent surface. Although these are not independent observations it would have been unethical not to check both surfaces when the possibility existed after tooth separation. Adjacent surfaces were, therefore, included in this analysis.

For radiographic lesions observed in enamel, about one-fourth to one-third were cavitated, for radiographic lesions scored in outer dentine between 83.3–100% were cavitated, while almost all surfaces

Table I. Radiographic scores (observers 1–5) and distribution of cavitated surfaces in parentheses for clinical validator 1 and 2.

	Obs1 Val1/Val2	Obs2 Val1/Val2	Obs3 Val1/Val2	Obs4 Val1/Val2	Obs5 Val1/Val2
Sound	25 (7)/25 (8)	13 (3)/13 (4)	14 (1)/14 (2)	21 (4)/21 (6)	20 (4)/20 (6)
Enamel	42 (11)/42 (15)	43 (12)/43 (14)	39 (10)/39 (13)	47 (15)/47 (18)	46 (13)/46 (17)
Outer dentine (≤ 1/3 of dentine)	34 (34)/34 (34)	42 (35)/42 (36)	45 (38)/45 (39)	29 (29)/29 (29)	31 (31)/31 (30)
Inner dentine (>1/3 of dentine)	25 (25)/25 (25)	28 (27)/28 (28)	28 (28)/28 (28)	29 (29)/29 (29)	29 (29)/29 (29)
Total	126 (77)/(82)	126 (77)/(82)	126 (77)/(82)	126 (77)/(82)	126 (77)/(82)

with radiographic scores in inner dentine were cavitated. This is in agreement with earlier studies, which found an increasing proportion of cavitated lesions with increasing radiographic depth. However, the percentage of cavitated surfaces was higher than in previous studies. This may be explained by the higher caries activity and a lack of access to fluoride for the study population. It is assumed that, with lack of fluoride, cavitation occurs at an earlier stage in the disease process; however, the mean age of this study population was 36 years. This may, therefore, indicate different disease progression than in the 'western' populations. It may be speculated that high caries activity and lack of fluoride may not be entirely responsible for cavitation in this population. It is, therefore, proposed that the disease activity may be different, which needs to be investigated in future studies.

The threshold for operative treatment decision with respect to radiographic lesion depth has been established for some western countries [13,14]. In our study it was observed that less than 50% of the lesions in enamel were cavitated and more than 80% of the lesions into dentine were cavitated. It is, therefore, proposed that, for this population when a lesion is present in the outer dentine radiographically, it should be treated operatively. The threshold for operative treatment for the study cohort may, therefore, be set between the radiographic lesion observed in enamel and that observed in dentine (Figure 1). It is also proposed that such a threshold for cavitation in relation to the radiographic depth should be ascertained for other populations as even within a country there might be large differences between population groups.

Only two studies [10,11] have assessed the relationship between lesion depth and surface cavitation from developing countries, all revealing a high percentage of cavitated lesions in the outer dentine (90% and 79%). It needs to be noted though that the definition of an outer dentinal lesions varied in previous studies. Some defined outer dentinal lesions as those involving half of the dentine [7,11], while some used the definition like in our study at the outer one-third of dentin [9]. The present study's definition of an outer dentinal lesion follows the International Caries Detection and Assessment System (ICDAS) recommendations [18]. Most of the studies done in western populations are quite old, over half of them more than 25 years old. It is, therefore, needed to repeat these studies in western populations using the ICDAS recommendations as well as to estimate the present applicability of the 'western guidelines' for other world populations.

To the best of our knowledge this is one of the few studies which looked into the relationship between cavitation and radiographic lesion depth in a population from a developing nation. Further, few of the previous studies have dealt with observer variation in the recording of clinical cavitation. This study also for the first time assessed the universal applicability of the western guidelines. It is revealed that if 'western guidelines' were applied, a substantial number of cavitated surfaces would be left untreated. It is also plausible from this study that the threshold for cavitation may be different for different parts of the world. It could, therefore, be hypothesized that there is a need to develop national guidelines and new standards for global populations. This needs to be supported by future longitudinal and comparative studies.

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