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Original Research Article

Treatment Decision Based on Radiographic Proximal Caries Lesion Depth and Angle

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Abstract

Objectives: The aim of this study is to establish accurate diagnostic treatment decision threshold of proximal carious lesion in relation to the angle and depth of radiolucency in radiographic image in Saudi population. ***Methods:*** Bitewing x-rays were examined to detect the level of lesion depth and angle. Criteria for lesion depth were divided into four categories (E1, E2, DEJ & D). Radiolucincies in the bitewing radiograph extending less than or equal to outer half of enamel(E1), more than the inner half of enamel and before DEJ(E2), at the Dentinoenamel junction(DEJ), less than or equal to the outer half of dentin(D). Angle and Depth were also measured using SIDEXIS XG software (Sirona, Bensheim, Germany). Clinically, cavitation was evaluated at proximal tooth surfaces directly after the extraction of the adjacent tooth or missing proximal contact with the adjacent tooth due to several different indications (Decayed, orthodontic reasons, etc.). Independent T-test was used to correlate between (lesion depth & angle of radiolucency) with clinical cavitation. Chi-square test was used to correlate lesion depth of four categories with clinical cavitation. ***Results:*** 116 approximal surfaces with (age mean=31 years old) had (41 cavitated, 75 non-cavitated) proximal surfaces. Premolar 56.9% and Molar 43.1%. There is significant relationship between cavitation and increasing depth in proximal surface that gave P-value= (0.000). A significant relationship was found between clinical cavitation and the angle of approximal enamel surface with P-value = (0.024). ***Conclusion:*** With limitations in this study, dentists should be aware of contrast of the approximal lesion angle (determined by three points, most coronal radiolucent point, the deepest axial point and the most apical radiolucent point) of bitewing x-rays to evaluate operative intervention in proximal surface. The more increase in angle the less tendency toward cavitation.

Keywords: Proximal caries, Demineralization, Lesion progression, Radiographic lesion depth, Cavitation.

INTRODUCTION

Dental caries is a multifactorial disease affecting the hard tissue (calcified) parts of the teeth, characterized by demineralization of the inorganic substances followed by destruction of the organic part of the tooth [1]. It is one of the most chronic diseases worldwide [2]. It affects 90% of adults in US [3] and 95% in Saudi Arabia [4]. Caries is caused by numerous environmental, behavioral, and lifestyle-related factors such as oral hygiene, high number of cariogenic bacteria, inadequate salivary flow, and insufficient fluoride exposure [2]. Therefore, the primary goal of every dental practitioner is to prevent the occurrence of caries by practicing preventive dentistry.

Early detection of carious lesions is important in providing good dental care. The detection of interproximal tooth surface caries is one of the most significant steps in the diagnosis and treatment of dental caries [5, 6]. Proximal caries progresses relatively slowly in permanent teeth and needs about 4 to 6 years to expand into the dentin [6, 7]. Aside from the basic concept of dental caries, little is known regarding the progression of dental caries lesions. It has long been known that not all lesions progress to cavitation [8]. It has been agreed that there is potential for non-cavitated enamel lesions to reverse, and the restorative intervention on non cavitated caries confined to enamel is inappropriate [9].

The detection of proximal lesions, particularly in early stages, has often been a diagnostic problem, especially when the proximal surfaces are inaccessible to direct inspection. Radiography is the most commonly used method, in addition to visual inspection. The method has reasonable sensitivity for caries confined to the dentin involving proximal surfaces, but it has quite a limited diagnostic value in lesions in the enamel [10]. Due to low sensitivity, both lesion depth and size are often underestimated and could remain undetected. Bitewing radiograph is still the state of the art as an adjunct in diagnosing carious lesions in clinically inaccessible proximal surfaces [11, 12]. There is a relationship between depth of radiolucency and cavitation. About 65–100% of radiolucency that extended into dentin are cavitated [13-16].

Bitewing radiographs help in estimating the lesion depth [17, 18]. However, it cannot precisely determine approximal caries progression [19, 20], and most importantly does not give any direct knowledge about surface integrity of proximal lesions [21]. Unfortunately, this does not solve the problem in determining whether a cavity is present or not.

The risk of cavitation in proximal carious lesions can be attributed to many factors. There is a relationship between probability of cavitation, depth radiolucency, age [22, 23], and gender [23]. Obese individuals are more susceptible to approximal caries than normal-weight individuals [24]. If cavitation is present, the lesion is considered irreversible, and restorative treatment is a necessity. Ideally, the clinical decision whether to restore the tooth should be made based on cavitation rather than histological lesion depth [25]. The exact relationship between macroscopic (clinical), histologic, and radiographic findings has still not been determined [26]. Prior studies have shown no valid threshold to intervene operatively in approximal lesions based on radiographic lesion depth. There are still variations among dentists in this particular matter. A previous study by Dental Practice Based Research Network (DPRN) included substantial variations among dentists on restorative treatment threshold based on radiographic lesion depth [27]. However, in Saudi Arabia, there is a lack of accurate clinical studies that have examined differences in treatment threshold at which practitioners would decide to intervene surgically for interproximal caries. Radiographic angle of proximal lesion is introduced as a new method to determine cavitation threshold at proximal caries surface.

The aim of this study was to establish an accurate diagnostic treatment decision threshold of proximal carious lesion in relation to the angle and depth of radiolucency in radiographic image in Saudi population.

MATERIALS AND METHODS

Ethical Concern and Study Design

A cross-sectional study was conducted on 116 Saudi adult patients (63 female and 53 male), ranging in age from 20 to 54 years (age mean=31). The patients, presenting with caries in 116 approximal surfaces (66 premolars and 50 molars), were treated at Riyadh colleges of Dentistry and Pharmacy (RCsDP). Approval from the Department of Research and Development at RCsDP was obtained before conducting the study. Written informed consent was obtained from all prior to examination. The recruited subjects each had at least one posterior tooth with new approximal lesion that extended to enamel, dentin, or beyond the DEJ and had no proximal contact with an adjacent tooth. Teeth with frank cavitation, severe rotation, or symptoms of pulpal inflammation were excluded.

Radiographic analysis

The bitewing radiograph images were exposed by one investigator using the same x-ray unit by Sirona Heliodent Plus Imaging System size 2 digital sensor, following the posted guidelines of total filtration 2 mm Al/70 kV using Heliodent Plus intraoral sensor positioner apparatus (Dentsply Sirona, Roma, Italy) to ensure precise reproducibility of angulation and distance in all images. The digital radiographic images were saved directly to the electronic patient record and then images were measured directly from a 19-inch computer monitor (Dell UltraSharp 1905FP, Dell Inc, Round Rock, TX, USA).

The measurements of lesion depth and angle were made three times using ruler and protractor of Sidexis XG software (Sirona, Bensheim, Germany) by one examiner and median of the measured value was recorded. Lesion depth in millimeters are radiolucencies in the bitewing radiographic image that extend from proximal height of contour to the deepest axial boundary as shown in Figure 1. Criteria for lesion depth were divided into four categories: radiolucencies in the bitewing radiographic image extending from proximal height of contour axially less than or equal to outer half of enamel (E1); more than the inner half of enamel and before DEJ (E2); at the dentin enamel junction (DEJ); and less than or equal to the outer half of dentin (D), as seen in Figure-2.

The approximal lesion angle (PLA) is determined by three points (A, B, and C). A point is the most coronal radiolucent point, B point is the deepest axial radiolucent point, and C point is the most apical radiolucent point forming PLA. Two PLAs were formed, PLA of enamel (PLAE) once the lesion in enamel surface and PLA of dentin (PLAD) once the lesion in dentin surface, shown in Figures 3 and 4.

Clinical Examination

Clinically, cavitation was evaluated at proximal tooth surfaces after the extraction of the adjacent tooth or missing proximal contact with the adjacent tooth due to several different indications (decayed, orthodontic reasons, etc.). The tactile examination was performed by one examiner three times in 10-second intervals by probing the suspected proximal site gently with a blunt explorer probe to avoid damage to the dental tissues. The examiner paused between examinations for 10 seconds to allow the tooth to dry.

The surface that was normal in texture and smooth was scored as intact (non-cavitated lesion). Cavity formation (cavitated lesion) was listed if surface breakdown was detected.

Statistical Analysis

Multiple statistical tests were conducted to analyze the results using (IBM SPSS Statistic for Windows, Version 22.0 Armonk, NY, US). Descriptive analysis of total sample factors was performed using percentage value. An independent T-test was used to correlate lesion depth and angle of radiolucency with clinical cavitation. Chi-square test was used to correlate lesion depth in categories (E1, E2, DEJ, D) with clinical cavitation.

RESULTS

Researchers assessed 116 approximal surfaces (premolar n=66 (56.9%) and molar n=50 (43.1%). Mesial surfaces were n= 48 (41. 4%) and distal surfaces were n=68 (58.6%). Surfaces in upper arch were n=48 (41.4%) and n=68 (58.6%) in lower arch. Surfaces on the right side of mouth were n=59(50.9%) and n=57(49.1%) on left side of the mouth. Clinically, n=41 were found to be cavitated (35.3%) and n=75 were found to be non-cavitated (64.7%).

During the clinical examination, 55 of the 116 lesions were in enamel (47.4%). In 13 proximal surfaces (11.2%), the non-cavitation was confined to outer half of enamel (E1=15) and in 30 proximal surfaces (25.8%) the non-cavitation was confined to inner half of enamel (E2=40), whereas, in twenty-six lesions (22.4%), the cavitation extended into dentin (D =42) Table-1.

Chi-square analysis showed a highly significant relationship (p<0.0001) between cavitation and lesion depths. A greater percentage of cavitation in dentin surface (D) is higher significantly than enamel surface categories (E1, E2) as shown in (Figure-5).

Independent T-test analysis showed significant difference (P-value =0.021) between mean lesion depths with clinical manifestation (cavitated and non-cavitated surfaces) and mean PLAE with clinical manifestation (cavitated and non-cavitated surfaces) (P-value =0.024).

The lesser the lesion depth and the greater the enamel angle, the less toward cavitation. On the other hand, PLAD has no significant relation with surface integrity (P-value = 0.881) (Table-2).

Pearson correlation coefficients (PC) showed that there is a correlation between clinical cavitation and PLAE with P-value = 0.024, which revealed that the greater enamel angle the less toward cavitation and vice versa. However, PC did not show any significant relationship between clinical cavitation and PLAD with a P-value = 0.881.

Table-1: Distribution of Approximal lesion surfaces by gender, tooth type, site, arch and clinical observational criteria and lesion extension

		Frequency	Percentage (%)
Site of Lesion	Mesial surface	48	41.4
	Distal surface	68	58.6
Gender	Male	53	45.7
	Female	63	54.3
Arch	Maxilla	48	41.4
	Mandible	68	58.6
Type of Tooth	Premolar	66	56.9
	Molar	50	43.1
Clinical Observational Criteria	Non Cavitated surface	75	64.7
	Cavitated surface	41	35.3
Lesion Depth Criteria	E1*	15	12.9
	E2**	40	34.5
	DEJ***	19	16.4
	D****	42	36.2
	Total	116	100.0

*E1: Carious lesion extending less than or equal to outer half of the Enamel, **E2: Carious lesion extending more than inner half of the Enamel and before DEJ, ***DEJ: Carious lesion at the Dentinoenamel junction, ****D: Carious lesion extending less than or equal to the outer half of the Dentin.

Table-2: Mean difference between Angle of Enamel, Angle of Dentin & Lesion Depth with Cavitation

	Surface Integrity	N	Mean	P-Value
Depth	Non cavitated	74	.9823	.021
	Cavitated	41	1.2400	
PLAE*	Non cavitated	75	95.9675	.024
	Cavitated	41	80.1227	
PLAD**	Non cavitated	17	91.4429	
	Cavitated	26	93.3088	.881

N: Number of surfaces. * Approximal lesion angle of Enamel, ** approximal lesion angle of Dentin.

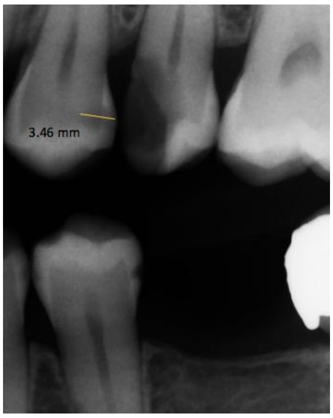

Fig-1: Bitewing radiograph image shows the radiographic measurement of an approximal caries lesion depth

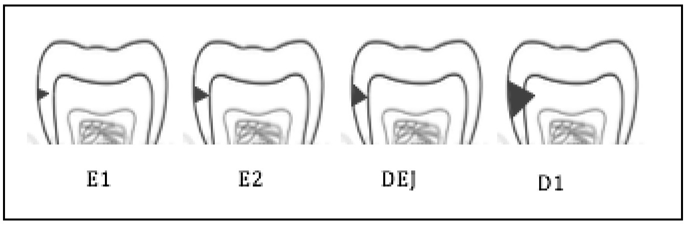

Fig-2: E1: carious lesion extending less than or equal to outer half of the Enamel, E2: carious lesion extending more than inner half of the Enamel and before DEJ, DEJ: carious lesion at the Dentinoenamel junction, D: carious lesion extending less than or equal to the outer half of the Dentin

Fig-3: Bitewing radiograph image shows the radiographic measurement of PLAE; A) The most coronal radiolucent point. B) The deepest axial radiolucent point. C) The most apical radiolucent

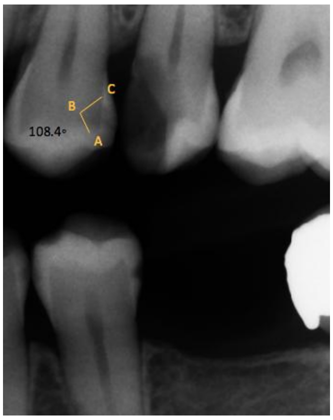

Fig-4: Bitewing radiograph image shows the radiographic measurement of PLAD; A) The most coronal radiolucent point. B) The deepest axial radiolucent point. C) The most apical radiolucent

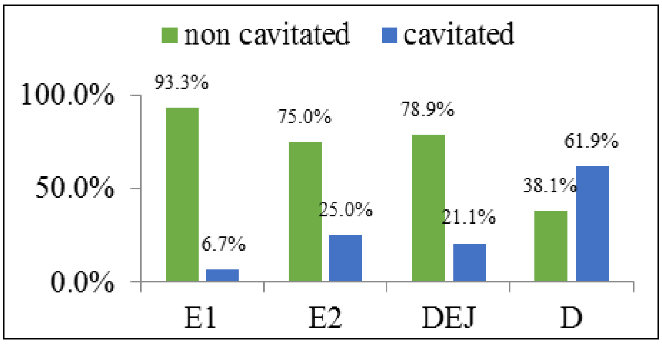

Fig-5: Relationship between Cavitation & Lesion depth (E1, E2, DEJ, D)

Discussion

Modern dentistry is approaching toward the concept of minimal intervention due to increased understanding of the caries process and the development of adhesive restorative materials. It is now recognized that demineralized, but non-cavitated, enamel, and dentin can be remineralized, and the need for the surgical approach 'extension for prevention' is no longer tenable as initially proposed by G V Black. Evaluation of radiographic proximal caries lesion depth and correlating it with clinical cavitation is of so much importance in order to get an accurate diagnostic threshold whether to operatively intervene or not. This is necessary elsewhere in the world and more important in a Saudi population as 95% of the population are affected by caries [4]. Most proximal surfaces in enamel and dentinoenamel junction in this study were non-cavitated. This was also confirmed by a study done by Akpata *et al*., [22].

According to Mejàre *et al*., [15] and Rugg-Gunn [28] who agreed all radiolucencies found in the dentin were cavitated, this does not apply in this study, where areas in D could still be non-cavitated. Regarding D zone, Pits and Rimmer [29] found a one-third rate of cavitation when radiolucency reached outer half of dentin. Studies done by Mejare and malmgren [30] and Akpata *et al*., [22] found cavitation prevalence of half and two-thirds, respectively, that increased as radiolucency reached the outer half of dentin. D zone is a critical zone. Similar results were found in this study; more than half of radiolucencies were cavitated but the remaining were still non-cavitated. It is difficult to confirm that all radiolucencies in the outer half of dentin should be restored since there is a chance that demineralization could occur.

Measurement of depth radiolucency was also considered in this study to have a relationship with cavitation, specifically that the increasing lesion depth meant a greater tendency toward cavitation. This also gave the same result when depth radiolucency was examined as category (E1, E2, DEJ and D) in enamel dentin surfaces, as the more approach to dentin the more tendency for cavitation.

In this study, the angle of proximal triangle radiolucencies was measured to detect the relationship between the angle and cavitation as a new method for determining operative intervention. After taking measurements, the relationship between the angle and enamel surface showed the greater the increase in the angle the less tendency there was toward cavitation. This could be related to the contrast of radiographic radiolucency. The greater contrast may mean more microorganism activity giving a higher tendency toward cavitation, and smaller spreads of radiolucency area. However, less microorganism action could appear radiographically with less contrast, and more areas of radiolucency, and hence, less destruction and tendency toward cavitation. A lower need to surgically intervene and preventive measures would be applied when a wider radiolucent area in enamel proximal surface is seen.

Depth radiolucency toward dentin surface should not be the sole basis for restorative decisions [31, 32]. Therefore, the width of enamel proximal surface should be considered when considering whether to drill and fill or wait and watch as a preventive choice of treatment.

Unfortunately, the angle of radiolucency in the dentin proximal surface had no relationship with cavitation. The reason behind that may be due to the substructure difference in the enamel and dentin surface. Another reason could be related to the enamel surface itself, as the radiolucent enamel angle could affect the angle in dentin surface. More investigations should be conducted to investigate this issue. Proximal width radiolucency in enamel surface should be considered as new method of determining whether to intervene surgically or not. The greater the angle with wider area of proximal radiolucency non-surgical treatment should be considered and vice versa.

More than half of the surfaces obtained in this study in outer half of dentin surface were cavitated but the remaining surfaces were not. This may lead to a decision about operative intervention cannot be determined as a cut off for treatment of radiolucencies in the outer half of dentin proximal surface.

Moreover, other factors should be considered, such as diet and caries risk, which are important factors in decision making for choice of treatment in a Saudi population. It is important to ensure that healthy low caries risk patients are not over treated and non-healthy high risk patients are not undertreated.

Future studies should aim to gain more data to correlate radiographic measurements of angle, lesion depth, and patient individual factors and their influence on cavitation through increasing sample size so that decisions about operative treatment can be determined as a cutoff line in a Saudi population.

Conclusion

With the limitations in this study, dentists should be aware of the contrast between the approximal lesion angle (determined by three points: most coronal radiolucent point, the deepest axial point, and the most apical radiolucent point) of bitewing x-rays to evaluate operative intervention in proximal surface. The more increase in angle the less tendency toward cavitation.

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