Diagnostic Challange: Instances Mimicking a Proximal Carious Lesion Detected by Bitewing Radiography

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Abstract

Prevention of more invasive restorative treatment modalities requires early caries diagnosis which dental clinicians face during everyday practice. The primary visual inspection method has partial reliability for detecting noncavitated lesions, especially on proximal surfaces. Thus, dentists regularly prefer bitewing radiographs as an adjunct method for diagnosis of the carious lesions. Many radiologic factors can affect the ability to accurately detect the carious lesions; exposure parameters, type of image receptor, image processing, display system, viewing conditions and visual illusions. Beside these radiologic factors, various morphologic phenomena, such as pits and fissures, dental anomalies, such as hypoplastic pits and concavities and acquired changes of dentition, such as abrasion and erosion can mimic the appearance of a carious lesion. Thus, the outcome of a false positive diagnose is the initiation of unnecessary invasive restorative treatment. Dentists' knowledge about the entities mimicking the proximal carious lesion detected by bitewing radiography is important for clinical practice to keep the patient out of these unnecessary treatments.

Key Words: Caries, False-positive diagnosis, Mach band, Cervical burnout, Bitewing radiography

Introduction

Dental caries is one of the most common chronic disease in the world [1]. It is challenging to make an early diagnosis of an incipient caries for every clinician and the varying appearance of the lesion may compromise the decision. Visual and radiographic examination are the most common adjunct methods in routine clinical practice for detecting caries lesions [2,3]. A carious lesion appears radiolucent in a radiographic image because the demineralized area of the tooth does not absorb as many X-ray photons as the unaffected mineralized portion. Bitewing, periapical and panoramic radiographic imaging techniques are routinely used in dentistry. Bitewing radiographs are especially valuable for detecting interproximal caries in the early stages of development before it becomes clinically visible. In this technique, the X-ray beam is aligned between the teeth and parallel with the occlusal plane to minimize overlapping of proximal surfaces. Because of the horizontal angle of the X-ray beam, these radiographs also may reveal secondary caries below restorations that may not be recognized in the periapical views [4-7].

Intraoral digital radiography has gained worldwide attention for caries diagnosis [8]. Two different methods are available; (1) solid state sensors (charge-coupled device (CCD) and complementary metal oxide semiconductor technology (CMOS) and (2) storage phosphors (photostimulable phosphor plates (PSP)) [7,9]. The phosphor plate system with competent diagnostic accuracy like conventional radiographs has been evaluated as an effective method for caries diagnosis [10-12]. Contrast and brightness adjustment, histogram equalization, noise reduction and magnification are the available image processing methods that may enhance the image quality in digital imaging [13,14]. Likewise, Moystad et al. [15] reported that PSP images that were enhanced with these methods improved the decision of approximal caries presence/absence. It was also reported that radiographic evaluation of the magnified images may improve the clinicians' ability to diagnose approximal caries lesions.

Diagnosis of incipient or secondary proximal or smooth surface caries and planning the best treatment options for them are the most common problems in clinical dentistry. Because the proximal surfaces of posterior teeth are often broad, the loss of small amounts of mineral from incipient lesions and the advancing front of active lesions are often difficult to detect in the image. Lesions limited to enamel may not be apparent until approximately 30% to 40% demineralization has occurred [7]. Owing to the fact that, restorative intervention is only required when caries lesion extends to enamel-dentin junction, radiography has superior advantages than visual inspection. However, if the lesion is restricted within enamel, both of the methods may be considered as insufficient in low caries prevalence populations and the number of false positive findings outweighs the number of additionally detected dentine lesions [16-18]. From that point of view, a clinical study confirmed that clinicians generally conclude many false-positive diagnoses of dentin lesions on approximal or occlusal surfaces. Totally, there were 21% false-positive diagnoses for approximal surfaces, and more than 70% of the dentists produced at least 20% false-positive diagnoses [19]. In addition, some researchers showed that dentists misdiagnosed the depth of lesions up to 40% by using conventional radiographs and in 20% of cases they misdiagnosed sound teeth as carious [20].

The decision of right treatment modality depends on appropriate diagnosis which may be particularly hampered in the absence of cavity. It should always be kept in mind that patients should be evaluated with their potential caries risk since unnecessary preparations may be conducted on low risk caries patients when high sensitive methods are used and the result will be numerous false positive results [21]. Diagnosis of incipient or secondary caries lesion is crucial to prevent progression of the lesion since the restorative treatment may be avoided and more conservative treatment modalities may be accomplished to prevent sacrificing healthy tooth substance. Unfortunately, there is no diagnostic device which is capable of both delivering a simple, reliable, sensitive and specific measurement of the size of carious lesion [22]. What

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is more, the ability of a clinician to recognize any incipient and secondary caries lesion may also be affected by the clinicians' skill, knowledge and experience, viewing conditions beside the physical shortcomings of radiology technology [23].

The outcome of a false positive diagnosis is the initiation of unnecessary invasive restorative treatment. The main idea beneath this preventive restorative approach to avoid false positive diagnose relies on the fact that resin-based restorations has a limited life time of 6-10 years with a median survival time of seven years [24]. Besides, apart from any false positive diagnosed lesion, each time a defective restoration is removed and replaced, the cavity becomes larger with removal of sound tooth structure and pulpal involvement may occur leading to more complex restorative solutions. Thus, it is of a modern dentist's duty to keep the patient out of this restoration cycle to delay those complex treatment options [24].

There are many different factors that can influence the ability to accurately detect these lesions. These may be exposure parameters, type of image receptor, image processing, display system, viewing conditions, and ultimately, the training and experience of the clinician [19,25]. Additionally, various morphologic phenomena, such as pits and fissures, cervical burnout, mach band effect, and dental anomalies, such as hypoplastic pits and concavities can mimic the appearance of a carious lesion [7].

Cervical burnout

Cervical burnout appears as a radiolucent band around the necks of teeth and is more pronounced at the proximal edges. The X-ray photons overpenetrate or burn out the thinner tooth edge and create the radiolucent area that mimics cervical caries [26] (*Figure 1*). However, carious lesions involving proximal surfaces are most commonly found in the area between the contact point and the free gingival margin. Therefore, this type of lesion does not start below the gingival margin helps distinguish a carious lesion from cervical burnout [7].

Figure 1. *The left bitewing image revealed the cervical burnout areas on distal cervical surfaces of maxillary canine and mandibular first premolar tooth.*

Mach band effect

This visual phenomenon first described by Erns Mach in 1865 [27]. The illusion is often spoken of as one of edge enhancement whereby when a uniformly dark shade meets a uniformly light shade, the dark shade seems to become even darker and the light shade lighter as they approach the interface, thereby enhancing the visualization of the edge [27-30]. Mach bands occur along the borders of structures with different radiographic densities [31]. The common explanation of this phenomenon as lateral inhibition of neural receptors by adjacent receptors of retina [28,31].

In dentistry, mach band effects may present diagnostic dilemmas when they show fictitious radiolucent areas inside the proximal dentin enamel junction in incisors and canines, less frequently in premolars and to the least extent in molars [26,28]. The mach band effect is also one reason for the darker appearance of dentinal peaks seen in bitewing radiographs of some premolars (usually mandibular premolars) where the dentin comes to a sharp peak in the corners bounded by occlusal and proximal enamel surfaces (*Figure 2*). In addition, the radiographs of the distal portion of mandibular canine crowns may also show superimposed images of the lower lip and adjacent radiolucent areas similar to mach band effects. This effect is more likely seen in properly exposed radiographs than underexposed or overexposed radiographs [26].

Figure 2. *The left bitewing image showed mach band effects on distal surface of maxillary first premolar and mesial surface of mandibular first molar.*

The mach band effect can be misinterpreted as caries and possibly lead to mistreatment. To avoid the misinterpreting this effect, masking the enamel of the radiograph with an opaque card or piece of paper can prove conclusive. Thus, lateral inhibition of receptors is canceled and mach band effect caused radiolucent area disappears. A true carious lesion produces an actual darkening and such a radiolucent area could not disappear by masking [26].

The perception of this effect is influenced by observers' experience. Not every observer has the same ability to perceive mach band effects. The dental students or recent graduates are made the most misinterpreting the mach band effects [28]. Also, when there is a sharply defined density difference, such as between amalgam fillings and dentin, there may appear to be a more radiolucent region immediately adjacent to the amalgam filling. This situation may lead to the number of false positive interpretations.

Background density effect

The background density effect is phenomenon related to mach band formation. The differences in background density may affect the perception of adjacent structures [29,31]. Daffner attributes, this effect derives from the same principal as mach band illusion, but in this case, rather than a proximal surface being accentuated, an entire area is emphasized by its background [31].

Optical illusion

When the interproximal surfaces of teeth superimposed on each other, a radiolucent line occurs on the radiographs as a result of optical illusion (*Figure 3*).

Figure 3. *Note the superimpositions on the approximal surfaces which leads to optical illusions on this bitewing images.*

Radiolucent restorative materials

Restorative materials vary in their appearance in the image depending on thickness, density, atomic number, and the X-ray beam energy used to make the image. Some materials can be confused with caries. Older calcium-hydroxide liners without barium, lead, or zinc (added to lend radiopacity) appear radiolucent and may resemble recurrent or residual caries. Older composite, plastic, or silicate restorations, especially adhesive systems may also be considered as a lesion (*Figure 4*) [7]. Hotta and Yamamoto reported that the radiopacity of adhesive systems is unsatisfactory to make adequate clinical diagnosis [32]. However, it is often possible to identify and differentiate these radiolucent materials from carious lesions by their well-defined and smooth outline reflecting the preparation or from their radiopaque liners [7].

Figure 4. *In this right bitewing image, the radiolucent areas observed on the mesial and distal aspects of maxillary second premolar that can be confused with carious lesion. However, these well-defined radiolucencies cause from radiolucent restorative materials.*

Dental anomalies

Dental enamel hypoplasia can confused with carious lesion on radiographs. Enamel hypoplasia is a quantitative defect associated with reduced thickness of enamel formed during the secretory stage of amelogenesis [33,34].

Figure 5. *In the right bitewing image, the radiolucenct area seen on cervical surface of maxillary first premolar teeth. This patient has bruxism and abraded areas on the tooth so the radiolucency on this image one of the abrasion area not caries.*

Acquired changes of dentition such as abrasion and erosion also can mimic the appearance of a carious lesion. Toothbrush abrasion is probably the most frequently observed type of injury to the dental hard tissues. Abraded teeth may become sensitive as the dentin is exposed. Occasionally, the radiolucencies simulate carious lesions located at the cervical region of the tooth (*Figure 5*). The differential diagnosis is accomplished with clinical inspection. Erosion of teeth results from a chemical action not involving bacteria. Although in many cases the cause is not apparent, in others it is obviously the contact of acid with teeth. Areas of erosion appear as radiolucent defects on the crown. Their margins may be either well defined or diffuse. A clinical examination usually resolves any questionable lesions [7].

Conclusion

In conclusion, several factors can affect the capability to accurately diagnose the proximal carious lesions especially when the lesions are limited to enamel. Even though bitewing projection is most useful radiographic technique to detect interproximal caries, it has some limitations such as radiographic visual illusions and in cases where the demineralized area is not yet visible in the image. Because of the fact that, a proximal carious lesion can be incorrectly detected or failure to detect the lesion. Therefore, visual inspection should be combined with radiographic examination and clinician must be aware of the instances mimicking a proximal carious lesions to avoid unnecessary invasive treatment.

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