Diagnosis of Dental Cracks by Digital Bitewing Imaging: A Laboratory Study

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Abstract:

Objective: The purpose of this study was to evaluate the diagnostic accuracy of using digital bitewing imaging technique for the diagnosis of dental cracks. **Materials and Methods:** In this study, 60 specimens of extracted human teeth were collected. Teeth were divided into two equal groups; control group and study group. Cracks were artificially created on the study group by repeated thermal cycling method using boiled water and liquid nitrogen. Then teeth were mixed in a random manner and then placed in a waxed arch block to simulate the human geometrical pattern in imaging. The roots of the teeth were embedded from 2 mm below the cemento-enamel junction to the root apex. Teeth cracks were examined by digital bitewing radiography and three observers evaluated the cracks independently and recorded the results respectively. **Results:** The validity of digital bitewing technique values showed poor level of accuracy on crack detection by 65.0 %. **Conclusion:** Within the limitation of this study, digital bitewing images showed poor level of accuracy so, would be considered of limited value in detecting tooth cracks.

Introduction:

A cracked tooth is defined as: a tooth with partial or complete line fractures on its surfaces either due to occlusal stress, filling defects, or trauma.[1] Crack tooth syndrome (CTS) is a term introduced by Cameron in 1964 identifying a fracture on teeth not involving the pulp. The classification of dental cracks has been categorized into five types; craze lines, fractured cusps, cracked teeth, split teeth, and vertical root fractures. Dental pain is the frequent sign of teeth cracking, so diagnosis is mandatory as early as possible because crack symptoms are in common with other conditions especially periapical pathologies and periodontal problems.[2]

The foundation of American Association of Endodontists (AAE) has been specifically concerned about the development of diagnostic methods for the issue of cracked teeth assessment and root fractures as a top research priority The diagnosis of dental-crack can be made by various methods through microscopic observation, dye stains, transillumination, fluorescence methods, and radiographical examination.[3] As the phenomena of crack has been of great interest and diagnostically challenging, clinicians seek for a simple and available diagnostic aid as radiographical imaging to detect as well as to reach a confirmed diagnosis along with clinical examination.

The use of radiographical diagnostic testing has been mandatory in the field of oral pathology and oral it is basically derived from information obtained from the patient's medical and dental histories in conjunction with other findings through oral examination. The signs and symptoms associated with disease and the additional information supported by radiographic imaging and laboratory tests are taken into consideration to reach the final diagnosis. The use of advanced imaging for most dental practitioners has been limited because of cost, availability, and radiation dose considerations.[4]

Lately, the use of digital radiography has been of great interest as an advent that has developed and updated the science of radiology. This revolution is the result of both technologic innovation in image acquisition processes and the development of networked computing systems for image retrieval and transmission. The main advantage of digitized radiographs is its ability to manipulate, improve and modify the quality of images electronically using various software programs consequently eliminating the mess of film processing and the hazards of lead foil. In addition, digital intraoral receptors require less radiation than film, thus lowering patient risk exposure.[5]

Bitewing radiography is a method of imaging used on posterior teeth mainly for the detection of interproximal dental decay. The digital modification of this imaging modality has shown an outstanding progress in the field of diagnostic dentistry, however; limited studies were known in their image accuracy for evaluating cracks. [6] Thus, the objective of this study is aimed to evaluate the accuracy level of digital bitewing imaging technique in the detection of dental crack.

Materials and Methods:

In this study, sixty intact extracted human teeth were used. They were extracted for periodontal and orthodontic reasons and collected from the department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Mansoura University after the approval of Research Ethics Committee. Teeth with intact enamel were selected to be included in this study. Teeth with any defect, attrition, fracture, caries or fillings, were excluded. At first, teeth were cleaned of all debris then were disinfected with sodium hypochlorite (1%) and stored in normal saline.

The specimens were randomly divided into two equal groups; control group where teeth with no further changes were done to them and the study group where artificial induced cracks were created on teeth. The procedure of inducing cracks was carried out by soaking teeth at first in hot water (100℃) for ten minutes and then quickly transferred into liquid nitrogen (-196℃) for one minute.[7]

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The procedure was repeated several times until cracks were observed on teeth surfaces (enamel or dentine). The presence of crack was confirmed and evaluated with the operating microscope and used as the gold standard. All teeth were mixed in a random manner and then placed in a waxed arch block to simulate the human geometrical pattern in imaging. Each block held four teeth arranged in the form of upper and lower arch shape then mounted in plaster.

The machine used for obtaining the digital bitewing radiographical images was Digora Optime PSP sensor (Sordex, Helsenki, Finland) with active area 31×41 and pixel size 64µm. The digital bitewing images were taken as a usual bitewing radiograph using an intra-oral phosphor plate that was placed on the lingual surface of all teeth on each model. Artificial grooves were made on each waxed block to fix the sensor in place to ensure a better positioning. Then the images were collected for the three observers for independent interpretation of scans and to detect the presence or absence of cracks on a two-point confidence scale as 0 for the crack absence and 1for the crack presence. Statistical analysis and data interpretation were fed to the computer and analyzed using IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using number and percent. Significance of the obtained results was judged at the (0.05) level. Kappa agreement was calculated by cross tabulation for categorical variables with Kappa (0.01–0.20: Slight agreement, 0.21– 0.40: Fair agreement, 0.41–0.60: Moderate agreement, 0.61–0.80: Substantial agreement and 0.81–0.99:0 perfect agreement).

Results:

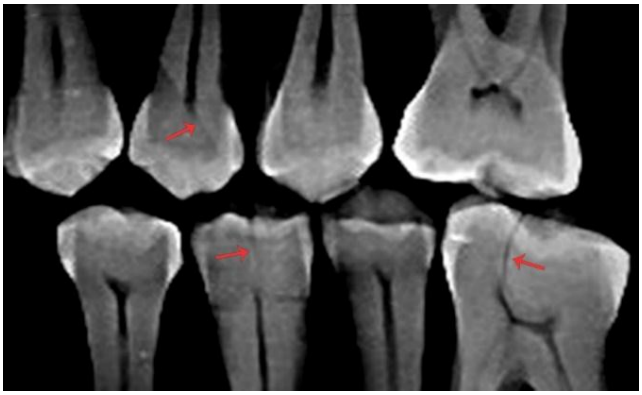
The validity of digital bitewing method illustrated that the accuracy for detection of crack is poor 65.0%. The sensitivity of this technique on detecting cracks was 0.30 and the specificity was 1 indicating that among all teeth, cracked and non-cracked, 30.0% of cracks could be detected and 100%of the non-cracked teeth could be ruled out through digital bitewing.

The positive predictive value was 1 while the negative predictive value 0.58 indicating that for a cracked tooth detected by digital bitewing, there is 100% confidence to say that the tooth has a crack. Moreover, for uncracked teeth detected by digital bitewing, there is only 58.8% confidence to say that the tooth is really free from crack.

The inter-observer agreement of digital bitewing technique used for crack detection was detected by Kappa agreement calculation between three observers and found to be poor 0.677 between the first and second observer. Between the first and third observers, the Kappa agreement was 0.833 and between the second and third observer it was 0.677 as shown in table below. The figure shows different areas of cracks detected by digital bitewing technique on posterior teeth.

Table (1): Showing the inter-observer agreement of digital bitewing technique used for crack detection

	1st vs. 2nd observer	1st vs. 3rd observer	2nd vs. 3rd observer
	K (95%CI)	K (95%CI)	K (95%CI)
Digital bitewing	0.67(0.381-.972)	0.83(0.617-1.0)	0.67(0.43-0.92)



Digital bitewing showing areas of crack on teeth (red arrows)

Discussion:

Several studies have been concerned about the diagnosis of dental cracks, and there is variety of methods used for this purpose. Conventional methods as intraoral radiographs were used for the diagnosis of teeth decay especially those with deep extensions.[8] Many radiographical techniques such as periapical radiographs and cone beam computed tomography have been used in detecting dental cracks.[9] Bitewing images in diagnosing dental cracks are not being much studied, the present study was designed to evaluate the validity of digital bitewing in dental crack detection.

The present study was carried out on 60 extracted sound teeth. Posterior teeth were only included in this study as cracks were shown to be more frequent in posterior teeth due to the effect of heavy occlusal forces. [10] Liquid nitrogen was used to create cracks on teeth as enamel will crack once subjected to repeated thermal cycling.[7] This method is less destructive than mechanically created cracks using burs; so resultant cracks were found to be distributed in several surfaces with various depths and length.

The results of the current study using bitewing for crack detection showed poor accuracy level. These results came in agreement with the study conducted by Steven Abrams[11] emphasizing that bitewing is not a reliable method in detecting dental cracks. The possible explanations for the poor sensitivity of the digital bitewing modality could be due to more than one factor; cracks were created randomly, not specified to the proximal surfaces. Also, its low validity in diagnosing early lesions by bitewing radiograph as it cannot always distinguish between sound surfaces and those with initial cracks. Bitewing radiographs also tend to underestimate the depths of lesions, so a small crack in the enamel with thickness less than 0.2mm could be hard to be shown in a bitewing image explaining the poor accuracy of digital bitewing radiograph in detecting tooth cracks.[11,12]

However, the results of Hyvönen et al.[13] generated a disagreement with this study outcomes on evaluating the

quality of digital bitewing on other situations beside caries detection and claimed that digital bitewing is useful in the diagnosis of teeth fractures (The expected justifications for this disagreement could be attributed to the large sample size they used in their study; in addition, their study scope was not confined only on dental cracks but they evaluated several parameters such as caries, restorations, root fillings and resorption.

Conclusion:

Digital bitewing radiographs are considered poor diagnostic tool for the detection of dental cracks.

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