Original Research

Agreement of Digital Panoramic Radiographs with and without Software Enhancement in the Diagnosis of Proximal Dental Caries in Primary Molars

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Abstract

Introduction: Dental caries is the most common chronic condition in children. Recently, there has been a growing tendency to using digital panoramic radiography among clinicians. The present study aimed to determine the accuracy of digital panoramic radiography with and without software enhancement in the diagnosis of proximal dental caries in primary molars. **Methods:** This study was conducted using 27 digital bitewings and panoramic radiography in 2016. Initially, panoramic radiography without enhancement was observed by a maxillofacial radiologist. Afterwards, sharpen, pseudocolor, emboss, and reverse-contrast enhancements were applied, and radiography was re-evaluated. In addition, bitewing radiography was investigated. After data collection, data analysis was performed in SPSS using the Kruskal-Wallis test and kappa coefficient agreement at 95% confidence interval. **Results:** No significant difference was observed between digital panoramic and bitewing radiography in the diagnosis of interproximal caries in primary molars. The maximum coefficient of agreement was obtained in maxillary and mandibular E (k=0.893) and maxillary and mandibular D (k=0.874 and k=0.897, respectively). Moreover, no significant differences were denoted between the enhancement tools in the diagnosis of interproximal caries (P>0.05). In general, sharpen four was found to be the most powerful tool in this regard.

Conclusion: According to the results, digital panoramic imaging system was as accurate as bitewing radiography in the diagnosis of proximal dental caries. However, using enhancement tools in panoramic radiography was not helpful in the diagnosis of caries.

Keywords: Proximal Caries, Panoramic Radiography, Bitewing Radiography.

Introduction

Dental caries is the most common chronic condition in children. Although effective methods have been proposed for the prevention and treatment of dental caries, there have been no signs of reduced needs for unmet treatments, especially in younger children. Diagnosis of dental caries prevents tooth pain, tooth extraction, and mental pressure in this population. Typically, dentists use eye, tactile, and radiography methods for the diagnosis of dental caries. The type of radiography for this purpose is decided based on age, size of oral cavity, and degree of patient cooperation (1). Although conventional radiography has acceptable diagnostic efficiency in assessing anatomical and pathological structures, digital radiography is considered to be a universal technology with promoted diagnostic efficiency in dentistry (2, 3).

Some of the key benefits of digital radiography include high-speed imaging, low radiation exposure, ease of use and storage, image manipulation, exchange of information to other centers without changing the quality of the images, no need for chemical solutions, and being environmentally-friendly, which saves significant amounts of time (4, 5). Interproximal caries lesions are often diagnosed by bitewing radiography. If a child is at the high risk of dental caries, bitewing radiography should be performed as soon as the posterior dental teeth are in proximal contact (1).

Bitewing radiography is considered to be the 'gold standard' for the diagnosis of interproximal caries, and the sensitivity of this method has been estimated at 40-60% (6). Nevertheless, some of the main limitations of this technique include patient discomfort, need for skilled practitioners, and increase in the received dose by the patient in the case of repeated radiography (7). Furthermore, panoramic radiography is used for tooth examination in children. Since the film is not placed inside the patient's mouth in panoramic radiography, it may be a better option for frightened, anxious or physically challenged children. Moreover, panoramic radiography does not trigger a nauseous reflux in the children with this condition. Another advantage of this method is that younger patients may find it entertaining and pleasant, which in turn results in their cooperation. However, some children lack the full immobilization tolerance for 15 seconds (1). Some of the findings in this regard have indicated that panoramic radiography has lower diagnostic accuracy in the case of caries compared to intraoral techniques (8). On the other hand, the report by Akkaya et al. (9) regarding the efficacy of panoramic radiography provided by new generation devices and the findings of Peltola et al. have suggested that radiography using new generation panoramic devices is comparable with bitewing radiography in their efficacy to diagnose tooth decay (10).

Recently, with the widespread use of digital radiography, there has been a growing tendency among clinicians to using digital panoramic radiography, so that several studies have been focused on the comparison of digital systems with conventional methods. Digital software systems enable the use of various methods, such as emboss, pseudo 3-D, reverse-contrast, pseudocolor, and sharpen enhancements. Evidently, evaluation of digital systems requires extensive research due to their variety and capabilities in different clinical cases (11).

It is notable that there has been a widespread demand on behalf of dentists for panoramic radiographs in the diagnosis of proximal caries of primary molars in children. Considering the limited studies regarding the efficiency of digital panoramic radiography software in the diagnosis of proximal caries, the present study aimed to evaluate the accuracy of digital panoramic radiography with and without enhancement software in the detection of proximal caries in primary molars.

Materials and Methods

This study was conducted in 2016 with the ethics code of 1394/60. By referring to a specialized oral radiology office, 27 bitewing and digital panoramic radiographs were selected, including 420 interdental surfaces of 19 female and eight male patients with the mean age of eight years. All the selected samples were prepared using a single device.

The inclusion criteria of the study were the presence of teeth E, D, and six in the four quadrants, patients with both digital panoramic and digital bitewing radiography, and proper quality of bitewing and digital panoramic radiography. The exclusion criteria were the presence of stainless steel crown, pulpectomized teeth, enormous repairs, and proximal overlaps.

Samples were collected for panoramic radiography and developed using the Cranex-D panoramic device (Soredex-Finland), and bitewing radiographs were developed using the photostimulable phosphor plate sensor (Digoraoptime, Finland).

Initially, panoramic radiography was observed without using enhancement tools by an oral maxillofacial radiologist on the monitor (Samsung, Korea) in semi-darkness using the Scanora software (version 4.3.1), and the caries between the primary molars (from mesial D to distal E, with contact with six) were recorded in each of the four quadrants based on their location.

After applying pseudocolor (Fig. 1), sharpen four, reverse-contrast, and emboss tools, the proximal caries in

Radiographic enhancement in diagnosis caries

panoramic radiography were recorded again. Since bitewing radiography is considered to be the 'gold standard' for panoramic accuracy, panoramic radiography was examined initially (Fig. 2). Evidently, the panoramic view could not affect the observation results of bitewing radiography.

Caries lesions were classified into four grades based on the following criteria: 1) absolutely non-existent; 2) probably non-existent; 3) probably existent and 4) definitely existent. A number was assigned to the mesial and distal levels of primary molars, and data analysis was performed using the Kruskal-Wallis test and kappa coefficient at the significance level of 5%.
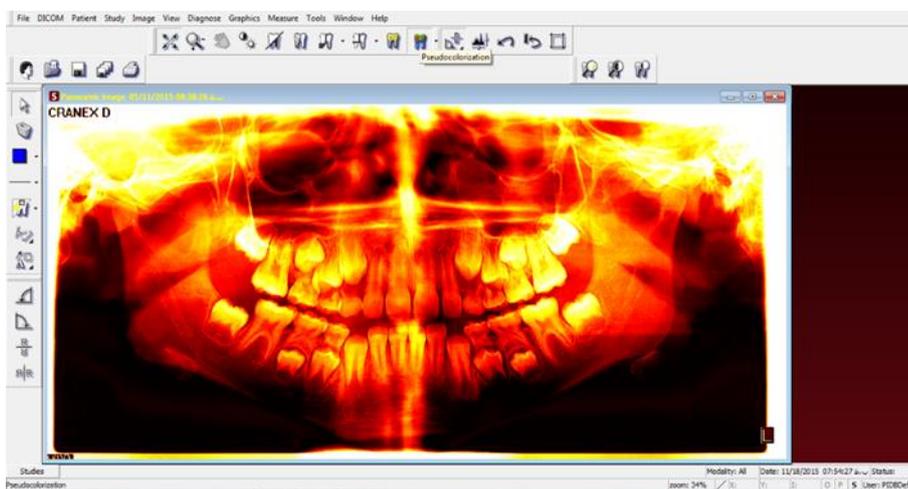

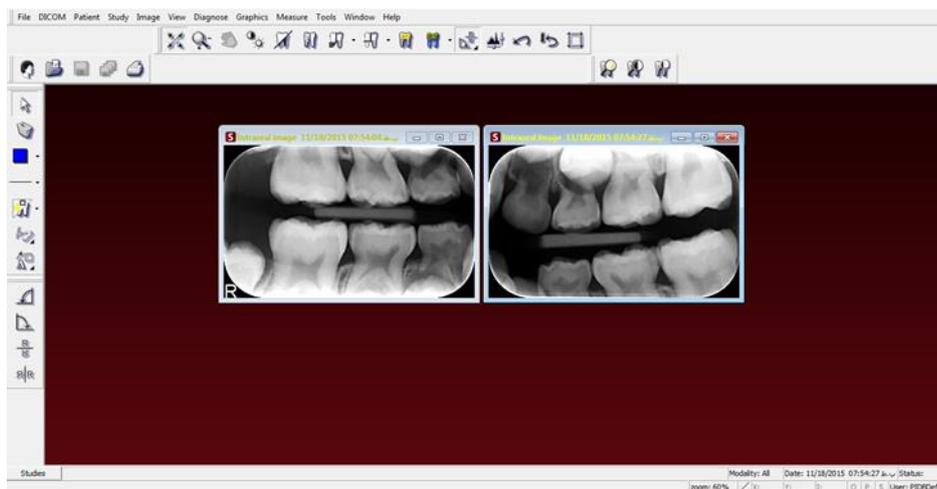**Figure 1.** Pseudocolor (HOT) Enhancement

Figure 2. Bitewing Radiography

Results

According to the information in Table I and kappa agreement coefficient, there was good agreement with the bitewing technique in the upper E region in all the techniques, and the maximum agreement between the bitewing and reverse-contrast tools was estimated at 0.893. In the lower E region, all the techniques had good agreement with the bitewing technique, and the maximum agreement was observed between bitewing and no enhancement. In the upper D region, all the techniques also had good agreement with the bitewing technique, and the maximum agreement between the bitewing and sharpen four tools was estimated at 0.874. On the other hand, in the lower D region, all the techniques had good agreement with the bitewing technique, and the maximum agreement was denoted between the bitewing and sharpen four tools at 0.897.

According to the information in Table II and results of the Kruskal-Wallis test, there was no significant difference between various tools in each of the specified teeth (P> 0.05). However, it could be stated that in all the areas of upper E, lower E, upper D, and lower D, sharpen four tools had the highest mean ranks.

Table I. Agreement between Panoramic Radiographs with and without Enhancement with Bitewing Radiography

Radiography / Region	P-value	Panoramic with Emboss	Panoramic with Reverse-contrast	Panoramic with Pseudo color	Panoramic with Sharpen Four	Panoramic without Enhancement
Upper E	0.570	262.31	262.31	267.00	277.33	258.35
Lower E	0.459	272.24	272.24	257.26	292.61	263.90
Upper D	0.906	263.28	263.28	276.38	279.34	265.30
Lower D	0.690	258.34	258.34	269.58	282.43	262.68

ƙ=Kappa Agreement Coefficient

Table II. Comparison of Diagnostic Accuracy of Panoramic Radiography with and without Enhancement in Primary Molars (numbers inside the table are mean ranks of scores)

Region / Radiography	Lower D	Upper D	Lower E	Upper E
Bitewing Radiography and Panoramic Radiography without Enhancement	ƙ=0.868 P=0.001	ƙ=0.858 P<0.001	ƙ=0.893 P<0.001	ƙ=0.864 P=0.001
Bitewing Radiography and Panoramic Radiography with Emboss Enhancement	ƙ=0.805 P<0.001	ƙ=0.835 P=0.001	ƙ=0.833 P=0.001	ƙ=0.867 P=0.001
Bitewing Radiography and Panoramic Radiography with Sharpen Four Enhancement	ƙ=0.897 P=0.001	ƙ=0.874 P=0.001	ƙ=0.887 P=0.001	ƙ=0.866 P=0.001
Bitewing Radiography and Panoramic Radiography with Pseudocolor Enhancement	ƙ=0.849 P=0.001	ƙ=0.819 P<0.001	ƙ=0.703 P=0.001	ƙ=0.773 P=0.001
Bitewing Radiography and Panoramic Radiography with Reverse-contrast Enhancement	ƙ=0.874 P<0.001	ƙ=0.872 P=0.001	ƙ=0.805 P=0.001	ƙ=0.893 P=0.001

Discussion

Due to the smoother and wider contact in primary molars compared to permanent molars, as well as the shortened enamel and wider pulpal horns, the earlier diagnosis of proximal caries seems impossible to be achieved using a sound, especially if the teeth are in contact without a distance (12). Radiographs are the main tools employed to detect dental caries. Timely diagnosis of interdental caries facilitates the treatment of these lesions and prevents their further development. Therefore, the diagnosis of interdental caries lesions via radiography is highly effective (9).

Panoramic techniques are the other commonly used dental procedures that are widely used in numerous cases, including the observation of large caries on the proximal dental surfaces. The advancement of technology has enabled the provision of this radiography with higher precision owing to the better imaging geometry and use of digital facilities. On the other hand, the limitations of the diagnostic efficiency of panoramic techniques could be due to the low resolution of the digital and geometric receptors of the special imaging in this method, which leads to the inherent distortion of the image, as well as the overlap of proximal surfaces.

Unlike panoramic radiography, bitewing radiography could illustrate the interdental small lesions with its high clarity of the intraoral films and imaging type, while benefiting from the parallel oral techniques. Therefore, despite the difficulty of bitewing radiography, its small field of view, and other disadvantages, it is the most viable option for searching for interdental caries (13).

In a study in this regard, Pontual et al. (14) concluded that the diagnostic accuracy of digital radiography in the detection of oral diseases is equal to or even higher compared to conventional radiography. Therefore, using digital panoramic systems is preferred for such purposes.

Nevertheless, limited studies have evaluated this software. The results of the present study were consistent with the findings of Akkaya et al. (9). The aforementioned studies also demonstrated that the accuracy of full-mouth intraoral radiographs was the same as panoramic and bitewing radiographs, while panoramic-only radiographs have been reported to be comparatively less accurate in the diagnosis of proximal caries.

In this regard, Nascimento et al. (15) conducted a study aiming to compare the diagnostic accuracy of various digital enhancement types. The obtained results indicated that the highest diagnostic value was filtered by sharpen, which had the most significant difference with the other images. In addition, the 3D emboss filter had the minimum diagnostic value, whereas the sharpen filter had the maximum diagnostic value. In another research, Zangooei et al. (16) aimed to investigate the effectiveness of the pseudocolor filter in the diagnosis of proximal caries. According to the findings, the pseudocolor filter could not improve the diagnosis of tooth decay. Similar to the current research, the mentioned study indicated that the digital tools did not contribute to the diagnosis of proximal caries.

In this regard, Tantanapornkul et al. (17) compared the efficiency of various image processing modalities. The emboss tool showed a significant difference, while no significant difference was observed between contrast brightness processing and inverted contrast. Furthermore, Akarslan et al. (6) assessed unfiltered digital panoramic images and three filtered images with sharpen, smooth, and emboss filters. According to the obtained results, the filtered panoramic images had the same or higher diagnostic accuracy compared to non-filtered radiographs, while the emboss filter had higher diagnostic accuracy than the other tools. In the present study, sharpen was observed to have a higher accuracy compared to the other filters.

In line with the findings of the previous studies in this regard (9, 15-16, 18), the results of the present study showed that digital panoramic radiography containing all the features of digital imaging systems, which increase the diagnostic accuracy of the systems as claimed by the manufacturer, cannot be equal to bitewing radiography in identifying interdental caries, and bitewing radiography remains the most viable option for the examination of interdental surfaces.

Limitations of the Study

There is the possibility of bias in the research findings due to the lack of appropriate time intervals for assessing the radiographs.

Conclusion

According to the results, providing digital panoramic radiography with a panoramic device could be used effectively for the diagnosis of proximal caries in the primary molars, along with bitewing radiography. However, applying the sharpen, pseudocolor, emboss, and reverse-contrast enhancements did not contribute to the detection of proximal caries, while they did not diminish the accuracy of caries diagnosis. In addition, no significant difference was observed between the mentioned diagnostic tools in the detection of proximal caries. In general, the sharpen four tool had the maximum diagnostic efficiency.

Conflict of interest

There are no conflicts of interest.

Acknowledgments

References

1. McDonald RE. McDonald′s and Avery′s Dentistry for the Child and Adolescent, 9th Ed. Mosby: 2011.

2. Borg E, Gröndahl HG. On The Dynamic Range of Different X-Ray Photon Detectors in Intra-Oral Radiography. A Comparison of Image Quality in Film, Charge-Coupled Device and Storage Phosphor Systems. Dentomaxillofac Radiol.1996; 25(2): 82-88.

3. Ørstavik D, Pitt Ford TR. Apical Periodontitis: Microbial Infection and Host Responses. Essential Endodontology. Prevention and Treatment of Apical Periodontitis. Oxford: Blackwell Science. 1998: 1-8.

4. Van Der Stelt PF. Filmless Imaging: The Uses of Digital Radiography in Dental Practice. J Am Dent Assoc. 2005; 136(10): 1379-1387.

5. Wenzel A, Gröndahl HG. Direct Digital Radiography In The Dental Office. Int J Dent. 1995; 45(1): 27-34.

6. Akarslan ZZ, Akdevelioglu M, Gungor K, Erten H. A Comparison of the Diagnostic Accuracy of Bitewing, Periapical, Unfiltered and Filtered Digital Panoramic Images for Approximal Caries Detection in Posterior Teeth. Dentomaxillofac Radiol. 2008; 37(8): 458-463.

7. Taylor-Weetman K, Wake B, Hyde C, House H, Park GF. Comparison of panoramic and bitewing radiography for the detection of dental caries: a systematic review of diagnostic tests. University of Birmingham, Department of Public Health and Epidemiology; 2002.

8. Rushton VE, Horner K, Worthington HV. Factors Influencing the Selection of Panoramic Radiography in General Dental Practice. J Dent. 19991; 27(8): 565-571.

9. Akkaya N, Kansu O, Kansu H, Cagirankaya LB, Arslan U. Comparing the accuracy of panoramic and intraoral radiography in the diagnosis of proximal caries. Dentomaxillofac Radiol. 2006; 35(3): 140-170.

10. Sakari Peltola J, Ventä I, Haahtela S, Lakoma A, Ylipaavalniemi P, Turtola L. Dental and oral radiographic findings in first-year university students in 1982 and 2002 in Helsinki, Finland. Acta Odontol Scand. 2006; 64(1): 6-42.

11. Goodarzipour D, Nejat S, Fotouhi A. Accuracy of digital panoramic in detection of interproximal caries. J Dent Med. 2011; 23(4): 36-41.

12. Clinical AC, American Academy of Pediatric Dentistry. Guideline on pediatric restorative dentistry. Pediatr Dent. 2012; 34(5):173-180.

13. Mehdizadeh M, Savar H. Assessing the diagnostic accuracy of filtered digital panoramic radiographs in detecting interproximal caries. Dent Res J (Isfahan) 2013; 8(7):629-636.

14. Pontual AA, De Melo DP, De Almeida SM, Boscolo FN, Haiterneto F. Comparison Of Digital Systems And Conventional Dental Film For The Detection Of Approximal Enamel Caries. Dentomaxillofac Radiol. 2010; 39(7): 431-436.

15. Nascimento HA, Ramos AC, Neves FS, de-Azevedo-Vaz SL, Freitas DQ. The 'Sharpen' filter improves the radiographic detection of vertical root fractures. Int Endod J. 2015; 48(5):428-434.

16. Booshehry MZ, Davari A, Ardakani FE, Nejad MR. Efficacy of Application of Pseudocolor Filters in the Detection of Interproximal Caries. J Dent Res Dent Clin Dent Prospect 2010; 4(3):79-82.

17. Tantanapornkul W, Mongkolrop P, Manoping P, Hannanta-Anant A, Prompruk E. Efficacy of Different Image Processing Programs in Detecting Small Artificial Caries Defects on Approximal Surfaces. Dentistry. 2012:2(3):112-129.

18. Baksi BG, Alpöz E, Soğur E, Mert A. Perception Of Anatomical Structures in Digitally Filtered and Conventional Panoramic Radiographs: A Clinical Evaluation. Dentomaxillofac Radiol. 2010; 39(7): 424-430.

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