Brief Report

# Image quality assessment in panoramic dental radiography: a comparative study between conventional and digital systems

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**Abstract:** This study is designed to compare and evaluate the diagnostic image quality of dental panoramic radiography between conventional and digital systems. Fifty-four panoramic images were collected and divided into three groups consisting of conventional, digital with and without post processing image. Each image was printed out and scored subjectively by two experienced dentists who were blinded to the exposure parameters and system protocols. The evaluation covers of anatomical coverage and structures, density and image contrast. The overall image quality score revealed that digital panoramic with post-processing scored the highest of 3.45±0.19, followed by digital panoramic system without post-processing and conventional panoramic system with corresponding scores of 3.33±0.33 and 2.06±0.40. In conclusion, images produced by digital panoramic system are better in diagnostic image quality than that from conventional panoramic system. Digital post-processing visualization can improve diagnostic quality significantly in terms of radiographic density and contrast.

**Key Words:** Conventional panoramic system; digital panoramic system; image quality assessment; panoramic dental radiography

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## Introduction

Digital panoramic imaging has become the latest technology of presenting radiographic details to the viewer for clinical diagnosis Application of digital panoramic images is burgeoning due to its benefits such as fast communication of images, small storage space required and minimum contamination to the environment (1,2). Moreover, digital panoramic technique have also further advances in dental imaging technology due to its advantages of providing optimal diagnostic images with low radiation dose when compared to the conventional technique (3-7). It has been reported that radiation dose in digital panoramic imaging was 5-14 μSv which is significantly lower than that of conventional panoramic imaging, which is 16-21 μSv (4). However, further dose reduction could be achieved up to 76% if the lowest possible radiographic protocol setting was applied (8). Nonetheless, there is always a tradeoff between the low-dose protocol setting and image quality. Therefore, the adjustment of image contrast and density in post-processing technique could improve the suboptimal quality image. This adjustment however, might not be sufficient to improve the sensitivity and specificity in the detection of dental pathologies and abnormalities (9). Although comparative studies have been conducted between digital and conventional dental panoramic images (9-14), there is limited evidence available in the literature to prove the superiority of digital panoramic technique over the conventional panoramic techniques. Therefore, this study is designed to compare and evaluate the diagnostic image quality of dental panoramic radiography between conventional and digital systems with the aim of providing knowledge and preference for dentists and dental radiographers in regards to the benefits and clinical practicality of dental imaging as a modality of choice.

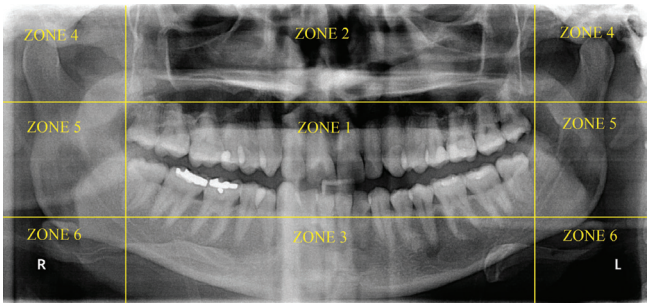


**Figure 1** The panoramic image was divided into six anatomical zones for anatomical structure evaluation. Nomenclature for each zone is defined as dentition (zone 1), nasal and sinus (zone 2), mandibular body (zone 3), temporal-mandibular joint (zone 4), ramus-spine (zone 5) and hyoid bone (zone 6)

## Materials and methods

This is a cross-sectional study comparing the image quality on panoramic images between conventional and digital panoramic systems in two major dental institutions, Diagnostic Imaging Department, Hospital Kuala Lumpur and Faculty of Dentistry, UKM, Malaysia. The study was approved by both institutional ethical review boards. The study was conducted retrospectively in both institutions between January and May 2011. Fifty-four panoramic images were collected in both institutions and divided into three groups consisting of conventional panoramic, digital panoramic and digital panoramic with post processing views. Details of the exposure parameters (i.e. kVp, mAs) were recorded from each image.

### *Conventional panoramic system*

Conventional panoramic imaging was performed with Orthosplus Ceph (Sinora, Benshein, Germany). The film-screen combination used was an Agfa CPG 400 speed class screen (Agfa, Gevaert, Belgium) with a Kodak T-Mat G/RA orthochromatic film (Eastman Kodak Co, Rochester, USA). Images were processed with a daylight loader DL 26 (Durr Dental AG, Bietigheim-Bissengen, Germany).

### *Digital panoramic system*

The panoramic images from digital system were collected and divided into two categories which involving with and without post-processing visualizations. The post-processing image involves modification of contrast and image density on 2D image in order to improve the overall image quality. The digital panoramic technique was performed on Planmeca Promax (Planmeca, Helsinki, Finland) with charged couple device. In addition, Fuji Medical dry imaging orthochromatic film with Fujifilm drypix 7000 processor (Fujifilm Corporation, Tokyo, Japan) was also used in this system. In the post-processing technique, Planmeca Dimaxis 4.0 software (Planmeca Inc., Roselle, USA) was used for contrast and density image adjustment. Median and sharpening filters were applied in order to reduce noise on the panoramic images.

### *Analysis of image quality*

Qualitative assessment of image quality was determined by two experienced dentists with at least 15 years of experience with panoramic radiography. The two reviewers were blinded to the exposure parameters and system protocols. All digitized images were printed out and therefore, both digital and conventional panoramic images were equally evaluated using illuminator. Each image was scored subjectively with a 4-point ordinal grading scale covering three major aspects which consisted of anatomical coverage, density and image contrast and also anatomical structures. The anatomical structures on panoramic image were divided into 6 anatomical zones namely: dentition (zone 1), nasal and sinus (zone 2), mandibular body (zone 3), temporal-mandibular joint (zone 4), ramus-spine (zone 5) and hyoid bone (zone 6) as shown in *Figure 1*. Each zone was evaluated individually. The average score was then calculated from those 6 anatomical zones, anatomical coverage, image density and contrast so as to represent the diagnostic quality of each panoramic image. Although different aspect of evaluations have different score remarks, the numerical order for the grading scale remained unchanged with the higher (score of 3 or 4) representing better image quality and the lower score (score of 1 or 2) indicating poorer image quality (14,15). Details of the ordinal grading scale are presented in *Table 1*.

### *Statistical analysis*

All data were entered into SPSS V17.0 (SPSS, version 17.0 for Windows, Chicago, Illinois, USA) for statistical analysis. A P-value of $<0.05$ was considered to indicate a statistically significant difference. The score values of diagnostic image quality were normally distributed in all conventional and digital panoramic groups. Those values were compared with one-way analysis of variance (ANOVA) for multi-factor

 

**Table 1** Image quality score descriptions

| Evaluation aspect | Image score | Description |
|---|---|---|
| Anatomy coverage | 1 | Inappropriate coverage and irrelevant to clinical needs. |
| | 2 | Sign of suspected coverage worthy for further inspection. |
| | 3 | Visibility of coverage relevant to the clinical needs. |
| | 4 | Appropriate and optimal coverage depending upon the clinical application. |
| Density and contrast | 1 | Poor density and inadequate contrast between the enamel and the dentine. |
| | 2 | Unsatisfactory density with adequate contrast between the enamel and the dentine. |
| | 3 | Satisfactory density and contrast between the enamel and the dentine. |
| | 4 | Excellent density and contrast between the enamel and the dentine. |
| Anatomical structures | 1 | Significant structures are not visible and no diagnosis is possible. |
| | 2 | Only broad detail seen, diagnosis is uncertain. |
| | 3 | Small details are visualize and probably possible for diagnosis. |
| | 4 | Fine details are visualized with certain possible diagnosis. |

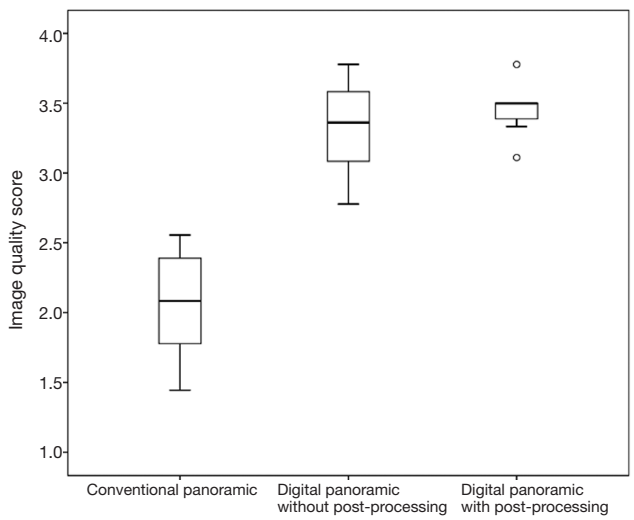


**Figure 2** Box plot shows the mean score of image quality reported in the studies with use of conventional panoramic, digital panoramic with and without post-processing technique. Image quality score in digital panoramic with post-processing technique is the highest amongst all of the three groups. The box indicates the first to third quartiles, with the line in the box indicating median quartile, and whiskers indicate the minimum and maximum values

interaction analysis. In addition, inter-observer agreement for subjective analysis was estimated by kappa statistics and classified as follows: poor ($\kappa$<0.20); fair ($\kappa$=0.21-0.40); moderate ($\kappa$=0.41-0.60); good ($\kappa$=0.61-0.80) and excellent agreement ($\kappa$=0.81-1.00). Kruskal-Wallis test was conducted for further statistical non-parametric analysis in qualitative image quality assessment.

## Results

The image quality was qualitatively scored by two independent dentists with a kappa score of 0.62, 0.61 and 0.65 corresponding to conventional, digital systems without and with post-processing respectively, indicating good inter-observer agreement. The overall image quality score revealed that digital panoramic with post-processing approach has the highest score of 3.45±0.19, followed by digital panoramic system without post-processing and conventional panoramic system with corresponding scores of 3.33±0.33 and 2.06±0.40, respectively, as shown in *Figure 2*.

Although digital panoramic imaging resulted in significantly higher image quality score than that in conventional panoramic imaging, there were no significant differences in the mean quality scores between post-processing and without post-processing images acquired with digital panoramic system (P=0.70). This is consistent with the image evaluation which was scored in anatomy coverage and anatomical structures (zone 1-6) where the differences in image scoring were only significant between the conventional and digital panoramic systems. However, the differences in image scoring between post-processing and without post-processing in digital panoramic systems were not statistically significant (P=0.35). In terms of the density and contrast aspects, the image quality score differed significantly among all groups (conventional panoramic versus digital panoramic without post-processing versus digital panoramic with post-processing). In addition, it also showed that post-processing visualization in digital panoramic imaging improved the image diagnostic value in

 

terms of density and contrast panoramic image.

## Discussion

This study demonstrates two main findings which are considered useful from the clinical perspective. Firstly, digital panoramic imaging produces significant better image quality compared to conventional panoramic. Secondly, diagnostic quality in digital panoramic imaging showed that images post-processing visualizations are presented with better density and contrast images, than images without post-processing. However, there are no significant differences in visualization of anatomical structures and coverage between post-processing and without post-processing images in digital panoramic system.

There were some contradictory results from previous studies on diagnostic image quality in comparing image quality of conventional with digital panoramic radiography. It has been reported in previous studies that there was no significant difference in diagnostic image quality between conventional and digital panoramic imaging (10,13,16). However, several studies stated that diagnostic image quality in conventional panoramic imaging was much better than that in digital panoramic radiography (3,14). Yalcinkaya *et al.* (3) observed that the differences in diagnostic image quality between conventional and digital panoramic were caused by the level variance of resolution and image noise. However, if digital panoramic images were evaluated by using an illuminator, the light increases the intensity which leads to improvement in diagnostic image quality. Since the screen monitor has limited resolution, image evaluation using illuminator (printed out) resulted in higher diagnostic score compared to that on the screen monitor (17). Therefore, those results should be interpreted with caution due to inconsistency in image evaluation method in which only conventional panoramic images were read through illuminator while the digital panoramic images were only visualized on the monitor screen. A previous study revealed that image assessment must be conducted consistently through illuminator in order to obtain consistent results (9). Thus, printing image is required for panoramic image evaluation in this study, regardless of digital or conventional panoramic systems.

In digital panoramic imaging, although image quality score with post-processing was better than that without post-processing technique, the comparative results remained statistically insignificant (P=0.70). Thus, it was aligned with Gijbels *et al.* (14) study which post-processing image did not give a significant impact on image quality improvement in terms of signal enhancement and noise reduction. However, earlier research findings were contradictory to our results in which image diagnostic value in digital panoramic imaging with computerized post-processing was significantly better than that without post-processing (18). Moreover, previous studies (3,6,19) concluded that post-processing image visualization of digital panoramic system with computational filters manipulation such as sharpening and median filters significantly improved diagnostic image quality. However, it depends on the post-processing technique itself which is operator dependent. Hence, a well-trained operator performing image post-processing technique with appropriate and correct filter will produce a high diagnostic of image quality (3).

A further assessment on computerized post-processing image was conducted to demonstrate that post-processed image produces an optimum density and contrast. Coincidently, manipulated image could also contain high image noise and artifact compared to the original panoramic image (3). Since the assessment of image quality is highly subjective, most dentists have shown their preference towards image with optimum density and contrast. In other words, the panoramic image remains to be regarded as high diagnostic value and in fact, received a good image quality score as long as the image density and contrast is optimum, regardless of the presence of artifact and more image noise (6). On the other hand, with proper computerized post-processing technique, details of anatomical structures can be displayed clearly. In addition, anatomical structures located at the low contrast area are also enhanced such as mandibular ramii and temporo-mandibular joints (TMJ) due to soft tissue shadow. It has also been demonstrated that post-processing technique can improve the diagnostic quality at the high density radiographic area such as hyoid bone, maxillary sinus and nasal area which leads to improvement in the accuracy of dental abnormality diagnosis (19,20).

In order to replace conventional panoramic system completely in clinical setting with a digital panoramic system, there are few clinical and practical requirements that need to be met. Firstly, the digital panoramic system must be able to produce an image of panoramic radiography with high diagnostic quality. Secondly, radiation dose associated with digital panoramic imaging should be less than or at least similar to that of conventional panoramic imaging. Thirdly, digital panoramic imaging must be compatible to the conventional panoramic generator for installation purpose. Fourthly, image signals produced at

 

the end of digital panoramic system must not be degraded which leads to the deprivation of image diagnostic value (lossless archiving). Finally, interoperability of digital image format is of paramount importance for data sharing purposes if necessary (17).

Some limitations exist in our study. Firstly, the image assessment was done by two viewers with different clinical backgrounds (periodontist and orthodontist). Although both viewers have adequate experience with panoramic images, the working environment which orthodontists are likely to use panoramic images more frequently than periodontists might influence the results for diagnostic assessment in this study. Secondly, post-processing technique is completely operator dependent. Therefore, image contrast and density modified by well-trained and experienced operator might influence the findings. However, avoiding the uncertainty can be achievable if using one operator to prepare the image for evaluation. Finally, our comparative study used two different panoramic imaging systems from different manufacturers. Therefore, certain features might vary significantly in both types of systems such as power output availability and technical parameters setting.

In conclusion, this study shows that images produced by digital panoramic system are better in diagnostic image quality than that from conventional panoramic system. Digital post-processing visualization can improve diagnostic quality significantly in terms of radiographic density and contrast. This finding also provides an insight into the current practices on the benefit of digital panoramic imaging in dental imaging.

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## References

1. Molander B, Gröndahl HG, Ekestubbe A. Quality of film-based and digital panoramic radiography. Dentomaxillofac Radiol 2004;33:32-6.
2. Visser H, Rödig T, Hermann KP. Dose reduction by direct-digital cephalometric radiography. Angle Orthod 2001;71:159-63.
3. Yalcinkaya S, Künzel A, Willers R, et al. Subjective image quality of digitally filtered radiographs acquired by the Durr Vistascan system compared with conventional radiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:643-51.
4. Visser H, Hermann KP, Bredemeier S, et al. Dose measurements comparing conventional and digital panoramic radiography. Mund Kiefer Gesichtschir 2000;4:213-6.
5. Garcia Silva MA, Wolf U, Heinicke F, et al. Effective dosages for recording Veraviewepocs dental panoramic images: analog film, digital, and panoramic scout for CBCT. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:571-7.
6. Kaeppler G, Dietz K, Reinert S. The effect of dose reduction on the detection of anatomical structures on panoramic radiographs. Dentomaxillofac Radiol 2006;35:271-7.
7. Dannewitz B, Hassfeld S, Eickholz P, et al. Effect of dose reduction in digital dental panoramic radiography on image quality. Dentomaxillofac Radiol 2002;31:50-5.
8. Gavala S, Donta C, Tsiklakis K, et al. Radiation dose reduction in direct digital panoramic radiography. Eur J Radiol 2009;71:42-8.
9. Angelopoulos C, Bedard A, Katz JO, et al. Digital panoramic radiography: An overview. Semin Orthod 2004;10:194-203.
10. Ramesh A, Tyndall DA, Ludlow JB. Evaluation of a new digital panoramic system: A comparison with film. Dentomaxillofac Radiol 2001;30:98-100.
11. Parissis N, Angelopoulos C, Mantegari S, et al. A comparison of panoramic image quality between a digital radiography storage phosphor system and a film-based system. J Contemp Dent Pract 2010;11:E009-16.
12. Luangjamekorn N, Williams N, Angelopoulos N. Digital panoramic radiography image quality: a comparison with film-based panoramic radiography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99:E25.
13. Makris N, Tsiklakis K, Alexiou KE, et al. The subjective image quality of conventional and digital panoramic radiography among 6 to 10 years old children. J Clin Pediatr Dent 2006;31:109-12.
14. Gijbels F, De Meyer AM, Bou Serhal C, et al. The subjective image quality of direct digital and conventional panoramic radiography. Clin Oral Investing 2000;4:162-7.
15. Commission E. European guidelines on quality standards for panoramic radiography. Luxemburg: European Union, 2004.

 

16. Benediktsdottir IS, Hintze H, Petersen JK, et al. Image quality of two solid state and three photostimulable phosphor plate digital panoramic systems and treatment planning of mandibular third molar removal. Dentomaxillofac Radiol 2003;32:39-44.
17. Gijbels F, Sanderink G, Pauwels H, et al. Subjective image quality of digital panoramic radiographs displayed on monitor and printed on various harcopy media. Clin Oral Invest 2004;8:25-9.
18. Fujita M, Kodera Y, Ogawa M, et al. Digital image processing of dentomaxillofacial radiographs. Oral Surg Oral Med Oral Pathol 1987;64:485-93.
19. Lehmann TM, Troeltsch E, Spitzer K. Image processing and enhancement provided by commercial dental software programmes. Dentomaxillofac Radiol 2002;32:264-72.
20. Sanden E, Koob A, Hassfeld S, et al. Reliability of digital radiography of interproximal dental caries. Am J Dent 2003;16:170-6.

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