Abstract

Analysis of the effect of photo-induced discharge on diagnostic accuracy

in digital intraoral radiography using imaging plates

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【Introduction】

An Imaging plate (IP) is a type of digital detector. In a digital intraoral radiography system using an IP, it has been reported that photo-induced discharge occurs when the X-ray-irradiated IP is exposed to visible light before image reading processing. Regarding the deterioration of image quality due to photo-induced discharge of the IP, there have been no reports of subjective evaluation of fluctuations in the illuminance of visible light exposed to the IP. Therefore, the purpose of this study was to subjectively evaluate and verify the effect of photo-induced discharge of the IP on diagnostic accuracy.

【Materials and methods】

Images processed by IP readers at Health Sciences University of Hokkaido Hospital and Health Sciences University of Hokkaido Dental Clinic were used. Images with image defects were extracted and classified from the collected images in digital intraoral radiography using an IP. In addition, the effects of image defects due to photo-induced discharge of the IP on the diagnostic accuracy of artificial alveolar bone defects in the mandible were investigated using continuous confidence method analysis (Receiver Operating Characteristic analysis : ROC analysis) for the following items.

1) Four levels of bone defects were created in the distal alveolar bone of the right first molar of the human desiccated mandible, depending on the depth.

2) X-ray radiography was performed using the standardized imaging device so that the three-dimensional X-ray projection direction was the same. The X-ray tube voltage was 60 kVp and 70 kVp, and the irradiation time was set to approximate the air kerma value of 0.6, 0.95, 1.2, and 1.55 mGy.

3) Before image reading processing, the X-ray irradiated IP was exposed to visible light to cause photo-induced discharge. The visible light illuminance was set at 150, 300, 600, and 900 Lx at the center of the IP, and the visible light exposure time was set at 15, 30, 45, and 60 s.

4) The IP image reading operation was performed in a semi-dark room with the illuminance of the work environment below 10 Lx. The IP reader was used to read the IP, and automatic density correction was performed as a standard setting for the image processing software.

5) The images read from the IPs were converted to DICOM format. In the DICOM conversion, anonymization and randomization of the image order were performed using the spreadsheet software to avoid variations in the observations of each evaluator.

6) The DICOM images were observed by the evaluators consisting of five dentists with more than 8 years of clinical experience. After each evaluator made the first observation, the second observation was made at least 2 weeks later. The image evaluation method used visual analog scale (VAS) to evaluate the state of bone defects on a scale of 0 to 10.

7) Using the dedicated software ROCKIT, the diagnostic accuracy of the images was objectively and quantitatively evaluated using the ROC curve. The Az value calculated by ROCKIT was analyzed using statistical analysis software.

8) Regarding the effect of image defects due to photo-induced discharge of the IP on diagnostic accuracy, we investigated the effects of differences in tube voltage and differences in air kerma. Furthermore, we also investigated the effects of differences in visible light exposure time (15, 30, 45, 60 s) and visible light illuminance (150, 300, 600, 900 Lx) on IP before image reading processing.

【Results】

1. We classified image defects obtained by digital intraoral radiography using an IP and investigated the frequency of image defect occurrence. As a result, the frequency of image defects in the collected images was 47.23%. Type-1 (white border on the image frame) accounted for the most number of image defects, with frequency of 97.87%, followed by Type-2 (slight rotation and tilt of the image) at 1.083%. The frequency of other types 3 to 6 was very low. It was suggested that the causes of Type-1 and Type-2 were mechanical errors that were difficult for operators to deal with.

2. As a result of investigating the effect of image defects due to photo-induced discharge of the IP on diagnostic accuracy, no significant differences were observed in the differences in tube voltage, air kerma, and exposure time of visible light to the IP before image reading processing. On the other hand, regarding the influence on diagnostic accuracy due to the difference in visible light illuminance on the IP before image

reading processing, the 600 Lx and 900 Lx curves were located lower than the 150 Lx and 300 Lx curves in the ROC curve. Furthermore, a significant difference was observed in the results of the F test for Az values.

【Discussion】

The causes of image defects can be divided into those caused by mechanical errors and those caused by human errors. The frequency of image defects at the two target facilities was 47.23%. This indicates that when images are acquired using an IP, defects are observed in approximately half of the images. Therefore, it was considered important to know its causes and how to deal with it. Furthermore, we investigated the effects of image defects due to photo-induced discharge of the IP on the diagnostic accuracy using a mandibular artificial alveolar bone defect model. It was suggested that exposing X-ray irradiated IP to higher illumination visible light significantly lowers the diagnostic accuracy.

【Conclusions】

Image defects in digital intraoral radiography unique to IP were classified into Type-1 to Type-6. As a result, Type-1 accounted for the most number of image defects, and the frequency of other Type-3 to Type-6 was very low. It was suggested that the causes of image defects Type-1 and Type-2 were mechanical errors that were difficult for operators to deal with.

Type-6 (images with high brightness over the entire area or images with finger-like dark areas) caused by photo-induced discharge of the IP was classified as a human error, and was the most frequently occurring image defect caused by human error.

In digital intraoral radiography using an IP, we subjectively evaluated the effect of image quality degradation due to photo-induced discharge of the IP on diagnostic accuracy using the artificial alveolar bone defect model using ROC analysis. As a result, the difference in X-ray irradiation conditions had no effect on diagnostic accuracy. On the other hand, it was suggested that exposing X-ray irradiated IP to higher illumination visible light significantly lowers the diagnostic accuracy.