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An Experimental Study to Measure the MTF of Diagnostic X-ray Imaging Systems Using Synchrotron Radiation

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Introduction

The estimation of image quality for X-ray imaging systems is essential for the generation of clinical images. Estimation involves physical and psychological estimation methods. Images that score the highest in both methods are used in clinical practice.

In the physical estimation methods, MTF is commonly used to evaluate sharpness, but because conventional MTF measurements utilize continuous spectrum X-rays like those used in diagnostic X-ray equipments, the accuracy of the measurements is limited by the influence of the focal spot size of the X-ray tube and the instability of the luminescence efficiency of the intensifying screen [1].

Therefore, in this study, in order to improve the accuracy of MTF measurements of analog imaging systems and to use the results of the measurements for clinical applications, we attempted to measure their MTF using a contrast method that utilizes monochromatic X-rays from synchrotron radiation.

Experiment

X-ray experimental station; BL-14C. analog imaging system (250×300mm^2); Ortho system (Gd phosphor intensifying screen + orthochromatic X-ray film). square wave chart; Pb 0.05 mm, maximal spatial frequency 10 Lp/mm. densitometer; apertur: 2mmϕ. microdensitometer; aperture 10×100 μm^2.

The monochromatic X-ray was set at 33 keV, the irradiation distance was set at 110 cm, and the radiation field was set at 40 × 40 mm^2.

1. eration of squar wave chart images and density distributions:

(i) X-ray irradiation:

First, we divided the analog imaging systems into 2 groups and set the irradiation time (10 s) in such a way that the densitometer would show density of input signals of about 1.50 at a spatial frequency of 0.0 Lp/mm, without Pb. Two images per film were generated. Subsequently, we also generated 2 images using the same irradiation time at spatial frequencies of 3.0, 4.0, 5.0, 6.0, 8.0 and 10.0 Lp/mm (output signal).

(ii) Density measurements:

Density were measured using a microdensitometer at a stage travel speed of 0.05 mm/s.

(iii) Density distribution:

The density distributions of input signals and output signals were generated from the results of the density measurements.

2. ulation and reading of the MTF:

Using characteristic curves, we converted the density distribution to X-ray intensities, calculated the square wave MTF, and computed the sine wave MTF (MTF values) according to the Coltman´s formula. The MTF values are shown in Figure 1.

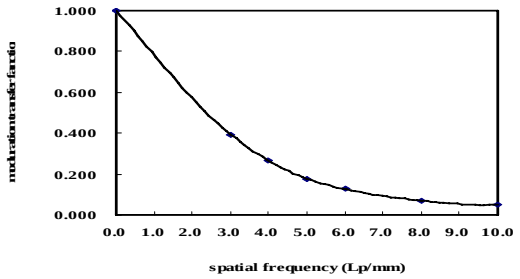

Figure 1. MFT

Conclusion

The results of the measurements showed an input contrast of about 0.6 and an MTF value of about 0.4 at 3.0 Lp/mm. There was little reduction in contrast at high spatial frequencies. Therefore, it was considered that the MTF of the analog imaging systems, which were measured with an irradiation distance of 110 cm, were reflected with high efficiency in the characteristics of the synchrotron radiation.

Therefore, the measurements conducted in this study allowed to determine that the irradiation distance causes little reduction in contrast, and inferred that monochromatic X-rays are uniformly incident to the imaging systems.

Thus, the MTF measurements performed using monochromatic X-rays from synchrotron radiation will contribute to the improvement of clinical imaging by making it possible to obtain highly accurate and sharp images from the imaging systems, and by making it possible to correlate the results of the measurements with the degree of visualization of the details of the tested materials.

In the future, we will measure the MTF of diagnostic X-rays by using measurement methods similar to those performed in this study, and we will compare the MTF of monochromatic X-rays with those of diagnostic X-rays. After that, we plan to conduct measurements in clinical situations in which the tested material (acrylic phantom) is attached to the imaging system.

Reference

[1] J. Papp: Quality Management in the Imaging Sciences, 3rd ed., Mosby Inc.328(2006).

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