Measurement of Imaging Property of Flat-Panel Detector

Masao Matsumoto [a], Kouji Suekane [a], Kouji Maeda [a], Yuji Ogata [a],
Kiyonari Inamura [a], Kouzo Kanai [b], Hitoshi Kanamori [c]

[a] School of Allied Health Sciences, Faculty of Medicine, Osaka University, Suita, Osaka, 565-0871 Japan, [b] R&D Sec. Osaka Branch, Toyo Medic Co. Ltd., Osaka, 500-0014, Japan, [c] Prof. Emeritus, Kyoto Institute of Technology, Kyoto, 606-0831, Japan
e-mail: matsumot@sahs.med.osaka-u.ac.jp

ABSTRACT

We measured and evaluated digital, pre-sampling and overall imaging properties (characteristic curves, Modulation Transfer Function (MTF), Wiener spectra (WS), Noise Equivalent Quanta (NEQ) and Detective Quantum Efficiency (DQE)) for the direct type and indirect type of Flat-Panel Detector (FPD). First, the digital and overall characteristic curves of the both types of FPD had more wide dynamic range than that of the S/F system. Second, the pre-sampling and overall MTF of the direct-type FPD were superior to those of the indirect-type FPD. Third, for identical exposures, the digital and overall WS of the direct-type FPD were similar or worse than those of the indirect-type FPD, and for larger exposure, the digital WS of the both types of FPD were smaller, but overall WS of the both types of FPD were larger. Fourth, the digital and overall NEQ and DQE of the direct-type FPD were worse than both NEQ and DQE of the indirect-type FPD at lower spatial frequencies, but were better at higher spatial frequencies.

Keywords: Flat-panel detector, imaging property, MTF, Wiener spectrum, NEQ, DQE

1. INTRODUCTION

A Flat-Panel Detector (FPD) has many advantages such as eliminating cassette handling and being able to display a pre-view image immediately in addition to the digital image processing and the networking. Thus, the FPD has ability to innovate the radiology department. We measure and evaluate pre-sampling and overall imaging properties (characteristic curves, Modulation Transfer Functions (MTFs), Wiener spectra (WS), Noise Equivalent Quanta (NEQ) and Detective Quantum Efficiency (DQE)) for direct-type FPD (Hologic EPEX Direct Digital General Radiographic System: pixel size 139μm, matrix size 2560×3072, field size 35cm×43cm) and indirect-type FPD (X-ray generator + tube: Toshiba Inverter KXO-80F + Varian A-192 and Canon CXDI-11 System: pixel size 160μm, matrix size 2688×2688, field size 43cm×43cm)[1--5].

2. METHOD

2.1 Measurement of digital characteristic curves

Digital characteristic curves were measured by the time scale method that changed mAs values at tube voltage 80kV with added 20-mmAl filtered x-ray tube. Focus-FPD Distance (FFD) was 100cm.

2.2 Measurement and calculation of MTF

(1) Measurement of MTF

$MTF\ (q\ ,\ \nu)$ was measured by using the tungsten slit (wide $10\,\mu$m, length 3mm) method by tipping 2 or 3 degrees and shielding lead at tube voltage 80kV and 50mAs with added 20-mmAl filtered x-ray tube. FFD was 100cm.

(2) Calculation of MTF

$MTF\ (q\ ,\ \nu)$ was calculated by Fast Fourier Transform (FFT) method with the composite Line Spread Function (LSF) calculated from the profile curves of many alignments for the slit image.

2.3 Calculation of WS

$WS\ (q\ ,\ \nu)$ were calculated by using the exposure data being changed from the pixel data by the measured digital characteristic curves. The exposure data were sampling with virtual slit (1×19 pixels) at each 1024-points per

unit and were removed the trend from the sampling data, and were calculated by FFT method.

2.4 Calculation of NEQ

$NEQ\ (q\ ,\ \nu)$ were calculated from measured contrast γ of characteristic curves, $MTF(q\ ,\ \nu)$ and $WS\ (q\ ,\ \nu)$ by the following equation;

$$NEQ\ (q\ ,\ \nu) = (\ \gamma \log_{10} e)^2\ MTF(q\ ,\ \nu)\ /\ WS\ (q\ ,\ \nu)$$

2.5 Calculation of DQE

$DQE\ (q\ ,\ \nu)$ were calculated by the following equation;

$$DQE\ (q\ ,\ \nu) = (\ \gamma \log_{10} e)^2\ MTF(q\ ,\ \nu)\ /(S/N)_{in}^2 WS\ (q\ ,\ \nu)$$

where $(S/N)_{in}^2$ is square of signal-noise ratio of input.

2.6 Measurement and calculation of overall data

Overall data were calculated by the methods of 2.1 to 2.5 with the photographic densities of films being printed out the digital data by using laser printer (Fuji Medical FM-DPL for the direct-type FPD and Kodak MLP-190 for the indirect-type FPD.

3. RESULTS AND DISCUSSION

We measured and evaluated the digital, pre-sampling and overall imaging properties (characteristic curves, MTF, WS, NEQ and DQE) for direct type and indirect type of FPD. First, the digital and overall characteristic curves of the both types of FPD have linearity and more wide dynamic ranges than those of the Screen/Film (S/F) system as shown in Fig. 1 (a) and (b).Second, the pre-sampling and overall $MTF(q\ ,\ \nu)$ of the direct-type FPD were superior to those of the indirect-type FPD as shown in Fig. 2 (a) and (b). Third, for identical exposure, the digital and overall $WS\ (q\ ,\ \nu)$ of the direct-type FPD were similar or worse than those of the indirect-type FPD and for larger exposure, the digital $WS\ (q\ ,\ \nu)$ of the both types of FPD were smaller, but overall $WS\ (q\ ,\ \nu)$ of the both types of FPD were larger. For example, Fig. 3 (a) and (b) showed the digital and overall $WS\ (q\ ,\ \nu)$ of the both types of FPD at 80kV, 50 mAs. Fourth, the digital and overall $NEQ\ (q\ ,\ \nu)$ and $DQE\ (q\ ,\ \nu)$ of the direct-type FPD were worse than $NEQ\ (q\ ,\ \nu)$ and $DQE\ (q\ ,\ \nu)$ of the indirect-type FPD at lower spatial frequencies than 1.5~2.0mm^{-1}, but were better at higher spatial frequencies than 1.5~2.0mm^{-1} as shown in Figs. 4 and 5 (a) and (b).

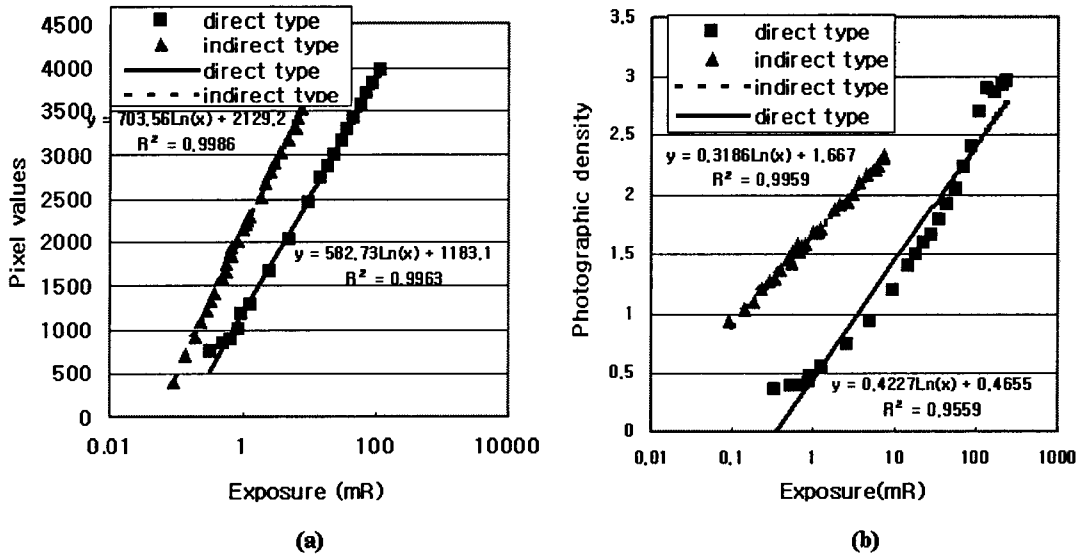


Fig. 1 Digital (a) and overall (b) characteristic curves for direct and indirect types of FPD.

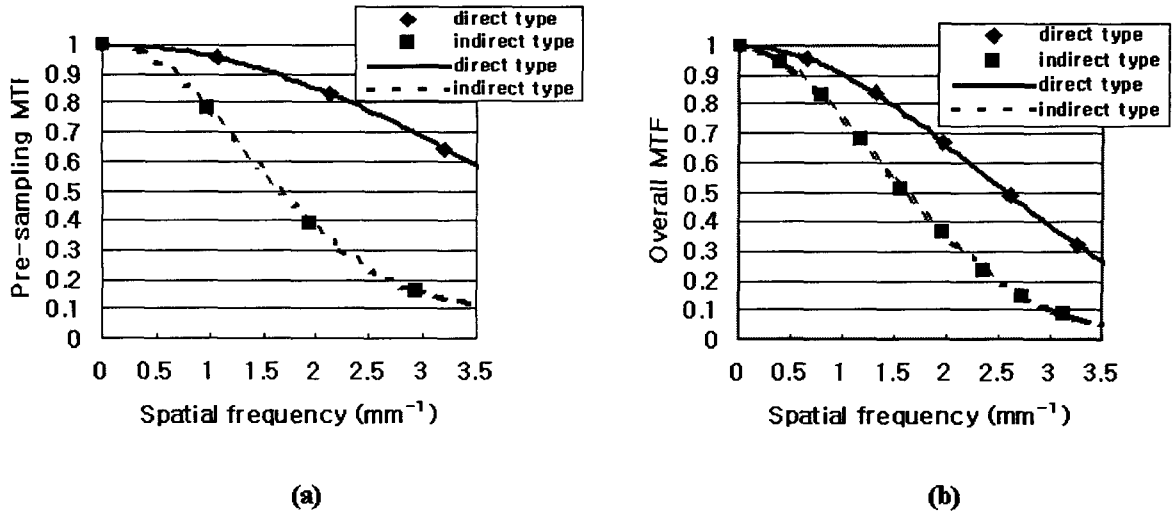


Fig. 2 Pre-sampling (a) and overall (b) *MTF* (q , ν) for direct and indirect types of FPD.

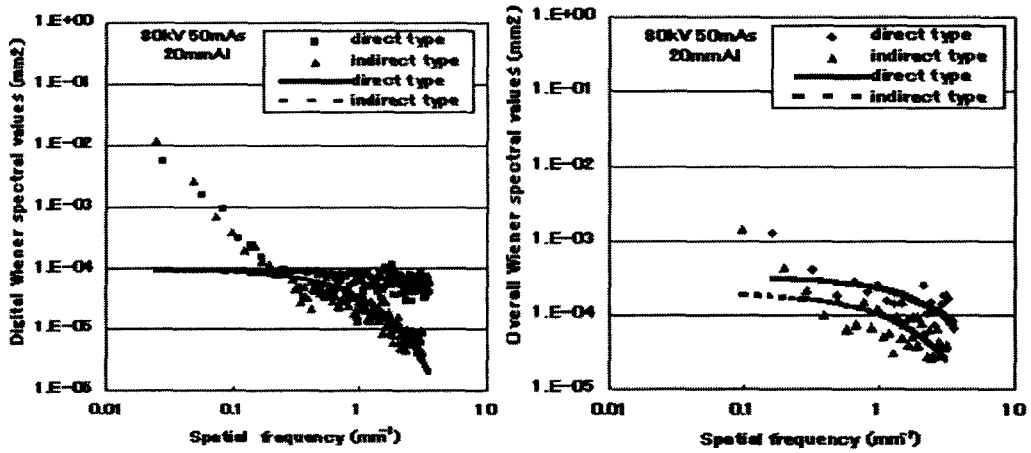


Fig. 3 Digital (a) and overall (b) *WS* (q , ν) for direct and indirect types of FPD.

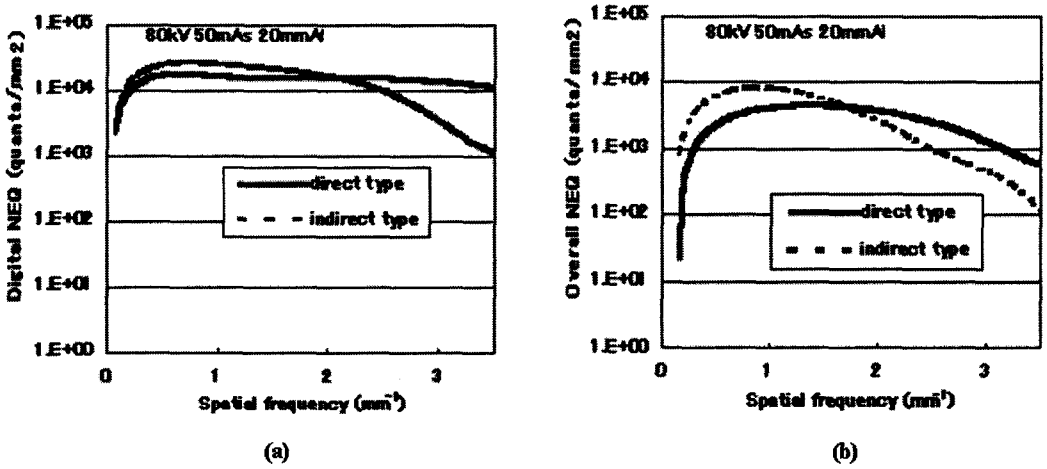
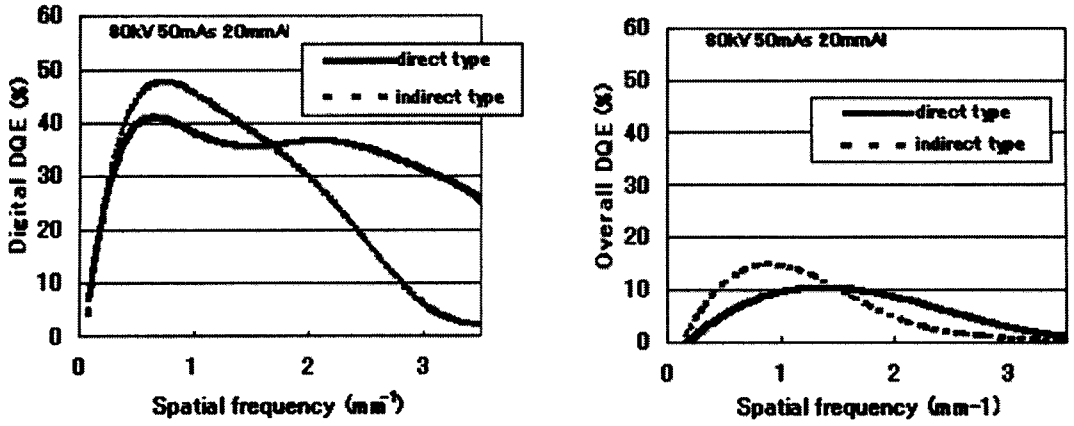


Fig. 4 Digital (a) and overall (b) *NEQ* (q , ν) for direct and indirect types of FPD.



(a) (b)

Fig. 5 Digital (a) and overall (b) $DQE(q, \nu)$ for direct and indirect types of FPD.

CONCLUSION

We measured and evaluated the digital, pre-sampling and overall imaging properties (characteristic curves, MTF, WS, NEQ and DQE) for direct type and indirect type of FPD. The digital pre-sampling and overall imaging properties of the both types of FPD were equivalent or better than those of S/F and FCR systems. The both types of FPD can take image data at real-time and be easy to digitalize. From these results, we can expect that the both types of FPD are useful machine by using digital image processing and so on in the radiology department.

5. REFERENCES

1) M. Matsumoto, K. Inamura. *Jpn. J. Medical Physics*. **20**, Sup.1, 17 (2000).
2) M. Matsumoto, K. Hisamori, K. Inamura et al. *J. Soc. Photo. Scie. Tech. Jpn.*. **63**(4), 210 (2000).
3) M. Matsumoto, K. Inamura., H. Kanamori et al. *Jpn. J. Medical Physics*. **21**, Sup.2, 48 (2001).
4) M. Matsumoto, K. Inamura. Radiology Frontier. **4**(4), 33 (2001).
5) M. Matsumoto, K. Suekane, Y. Ichimaru et al Proc. of International Congress of Imaging Science 2002, Tokyo 280-281 (2002).