

Experiences Using RADspeed safire with Auto-Stitching Radiography Function and Exposure-Reducing Collimator



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1. Introduction

The National Center for Geriatrics and Gerontology is located in Obu City, Aichi Prefecture, next to the Aichi Health Village Park. It offers 383 clinical beds and handles an average of approximately 450 outpatients per day. In mid-July 2010, the previous PET scanner was replaced by a 16-slice PET-CT system. A National Institute for Longevity Sciences, NCGG and the Center for Development of Advanced Medicine for Dementia, NCGG are located next door to the center. We collaborate with the adjacent laboratory to research ethically sound, high-quality treatments as part of our mission to contribute to the creation of a long-lived and healthy society. The hospital currently employs 15 X-ray technologists who strive diligently every day to handle leading-edge medical equipment.



Fig. 1 Entrance to the Hospital



Fig. 2 A National Institute for Longevity Sciences, NCGG

2. Background to Introducing the System

Between May and July 2010, we upgraded the equipment in three general radiography rooms. Flat panel detector systems were installed in all three rooms and CR cassettes are only used in cases where imaging is difficult with a flat panel detector (FPD). Flat panel detector systems were selected to improve the examination efficiency and enhance the quality of the digital images. We anticipated that they would also support filmless operation in accordance with the electronic medical records that have been used since 1 August 2010. The systems we introduced are Shimadzu RADspeed safire using direct-conversion FPDs. Direct-conversion FPDs were selected due to considerations of the examination time and contrast resolution. Direct-conversion flat panel detectors directly convert the input X-ray signals into electrical signals, without the intermediate conversion of X-rays to light required by conventional imaging processes. This completely eliminates the noise and data loss from the conversion process to achieve excellent contrast resolution that can faithfully represent even fine details. The major reason we selected RADspeed safire from the other FPD systems available is the auto-stitching radiography function. The short image synthesis time and the restraining belts and hand grips provided permit quicker and safer radiography than conventional CR cassette radiography.



Fig. 3 (a) Appearance of RADspeed safire; (b) Operation Panel; (c) RIS Console

Fig. 4 shows an overview of the RADspeed safire specifications. The image display time is the time between radiography and the image appearing on the console. The imaging cycle time is the time until the next radiography is possible.

System Specifications	
Item	Specification
Conversion Method	Direct conversion
Conversion Elements	a-Se
Pixel Size	150 μ m
Effective Field of View	17 inch \times 17 inch
Imaging Cycle Time	8 sec
Image Display Time	3 sec
A/D Gradations	16-bit (65536 gradations)

Fig. 4 RADspeed safire Specifications

3. Auto-Stitching Radiography

The RADspeed safire system installed at this hospital includes the auto-stitching radiography function. This function is used for radiography of the lower extremities and full spine. A special shield, hand grips, and belts to restrain the patient's body are provided to permit radiography in safer postures than previously possible radiography using conventional CR cassette (**Fig. 5**). The irradiation field direction (vertical, horizontal), irradiation field size, number of images, and auto-stitching radiography reference position can be selected. The number of images and the auto-stitching radiography reference position, in particular, are much more convenient, smooth, and user-friendly to set than before this system was introduced. Previously, radiography was commonly performed using two 14 \times 17-inch cassettes. However, some large patients could not be contained within this radiography range. In such cases, three 14 \times 14-inch cassettes were used, but this operation was difficult to set up and could result in displacements in the synthesized image. Nowadays the selection of two or three images at each irradiation field size can be easily selected with a single button. In addition, the upper, lower, and arbitrary reference positions can be selected using a single button for the auto-stitching radiography reference position, making positioning much simpler than it used to be. Image synthesis is completed within 10 seconds after radiography and the synthesized image is displayed automatically, leading to a reduction in examination times.

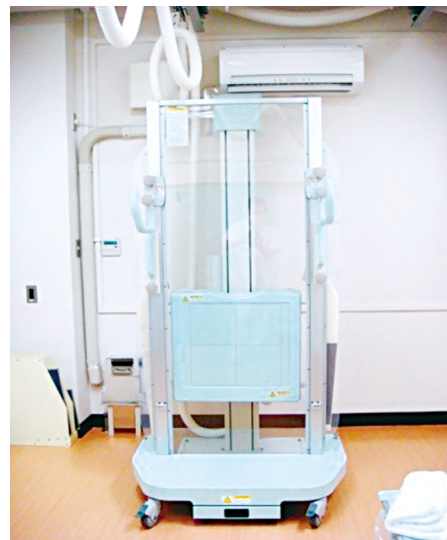


Fig. 5 Bucky Stand and Shield for Auto-Stitching Radiography

4. FPD Tilt Function

The RADspeed safire Bucky stand offers an FPD tilt function. The FPD can be tilted and fixed at 15°, 30°, 45°, 60°, or 90° forwards or 20° to the rear (**Fig. 6 and 7**). This permits radiography of the hands or elbows, without a CR cassette, and reduces examination times by eliminating the time previously required to read CR cassettes.



Fig. 6 90° Tilt



Fig. 7 45° Tilt

5. Dose Calculation Unit

The RADspeed safire we introduced is able to calculate and display the exposure dose before irradiation. The dose calculation unit measures the distance from the X-ray tube focal point to the skin surface using an ultrasonic distance meter attached to the collimator and calculates the X-ray exposure dose at the skin surface from the radiography conditions (Fig. 8). This value cannot be used for experiments or research, as slight errors may exist. However, the values delivered by this function are adequate as yardstick values to explain the degree of exposure dose to the patient.

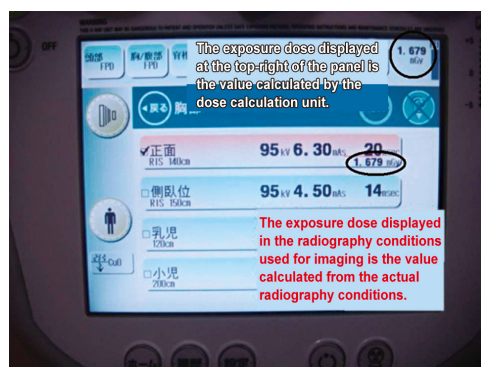


Fig. 8 Panel Display

6. Other Functions

After introducing this system, we found several other functions to be convenient. These include the field-of-view hold function and the interlock between the X-ray tube support and Bucky stand. The field-of-view hold function prevents the field of view size returning to its original value after a radiography item has been changed. This eliminates the effort of readjusting the field of view each time radiography is performed with a restricted field of view. The interlock function significantly improves work efficiency in comparison to adjusting the position each time, which was previously required. Consequently, introducing the RADspeed safire has led to shorter examination times.

7. Utility of the Exposure-Reducing Collimator

The RADspeed safire features a new collimator (Fig. 9) with the automatic filter function to reduce the exposure dose. It automatically inserts filters for each radiography menu item. The set filters are a 0.3 mm Cu filter for the chest and abdomen, 0.2 mm Cu filter for the spine, and 0.1 mm Cu filter for the limbs. We performed measurements using a water phantom to estimate the exposure dose reduction that can be anticipated when a copper filter is inserted.



Fig. 9 Collimator

7.1 Method

Constant radiography conditions (Fig. 10) were used for the measurements. The exposure dose was measured using a 0.1 mm, 0.2 mm, and 0.3 mm Cu filter and with no filter.

Conditions and Equipment	
Item	Value / Equipment
Tube Voltage	74kV
Tube Current	320mA
Time	250msec
Distance	150cm
Water Phantom	ORP-951 chest / abdominal water phantom (Orion Electric Co., Ltd.)
Dosimeter	Unfors Thinx (TORECK Co., Ltd.)

Fig. 10 Conditions and Equipment

The exposure dose was measured with and without the water phantom under the radiography conditions above. After the measurements, the dose measured with the water phantom was subtracted from the dose with no phantom to determine the dose absorbed by the phantom, that is, the X-ray exposure dose (Fig. 11).

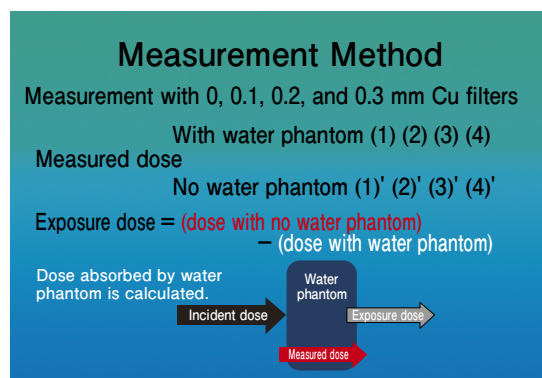


Fig. 11 Measurement Method

We used an ORP-951 chest / abdominal water phantom manufactured by Orion Electric Co., Ltd. for these tests. It has a two-layer construction. It is used as a chest phantom when water is inserted into the outside only, leaving an air space in the center. It is used as an abdominal phantom when all spaces are filled with water. For these tests, we filled all spaces with water and used the water phantom as an abdominal phantom (Fig. 12).



Fig. 12 Chest / Abdominal Water Phantom and Dosimeter

Next, to compare the exposure dose under radiography conditions (mAs value) that result in the same dose reaching the FPD both with and without a filter, the mAs value was determined that achieves the same S value after radiography as when no filter is used. Radiography was performed with a filter inserted and mAs set to several points (surrounding the target S value) to achieve an S value as close as possible to the S value with no filter. The mAs value to achieve the target S value was then selected from the fitted curve.

The exposure dose at the mAs value determined by this procedure was calculated as a proportion of the pre-measured dose.

7.2 Results

Fig. 13 shows the measured results under the same radiography conditions. **Fig. 14** shows dose comparison results when the S value is kept constant.

The comparison under the same radiography conditions shows a significant decrease in exposure dose when a filter is used. However, the filter also causes a simultaneous drop off in the dose reaching the FPD and a subsequent deterioration in graininess. The comparison of the dose reaching the FPD when the S value is kept constant reveals that the 0.1 mm Cu filter achieves a 39.7 % reduction in exposure dose in comparison to when no filter is used, the 0.2 mm Cu filter achieves a 53.7 % reduction, and the 0.3 mm Cu filter achieves a 58.3 % reduction, resulting in a significant exposure dose reduction.

7.3 Discussions

The copper filters are inserted to eliminate the soft X-rays. The use of a filter cuts out the low-energy components and reduces the dose reaching the detector, resulting in reduced image contrast and poorer graininess. These problems can be overcome in actual radiography by using the automatic density adjustment function to compensate for the decrease in contrast and by slightly increasing the radiography time to prevent any deterioration in graininess when a copper filter is used. It can be seen from **Fig. 14** that if a copper filter is inserted, an adequate reduction in exposure dose can be achieved even if the mAs value is set to a larger value than when no filter is used.

For actual clinical radiography, there is almost no distinct change in image quality whether or not a filter is used. However, the filter can significantly reduce the exposure dose, which confirms the utility of copper filters.

We were unable to test whether an excessive load is applied to the X-ray tube due to the radiography time being set longer than normal and we could not determine the effects on image quality of patient movements due to the longer radiography time.

Measured Results			
Cu	No Water Phantom	Water Phantom	Exposure Dose
0	2250 μ Gy	55 μ Gy	2195 μ Gy
0.1	1080 μ Gy	42 μ Gy	1038 μ Gy
0.2	685 μ Gy	34 μ Gy	651 μ Gy
0.3	490 μ Gy	27 μ Gy	463 μ Gy

Fig. 13 Exposure Dose at 74 kV, 80 mAs

Measured Results			
Cu	mAs to Achieve Same S Value	Exposure Dose	Reduction Dose
0	(80) mAs	2195 μ Gy	—
0.1	102 mAs	1323 μ Gy	39.7%
0.2	125 mAs	1017 μ Gy	53.7%
0.3	158 mAs	914 μ Gy	58.3%

Fig. 14 Comparison of Exposure Dose at the Same S Value

8. Conclusions

We investigated the effectiveness of the exposure-reducing collimator in the RADspeed safire installed at our hospital. While there is room for further investigations into the radiography conditions and filter selection, we realized that the collimator is extremely effective. The introduction of this system enhanced the staff work efficiency and reduced the examination times. As the conditions can be set from inside the examination room, the examination can be performed without taking your eyes off the patient. The restraining belts and hand grips enhance safety for elderly patients. In addition to its ease of operation, the system is designed with the patient in mind, with due consideration of safety and reducing the exposure dose. I look forward to further developments of such systems in the future.