

Experience of Using Slot Radiography – Experimental Use for Lower Extremity Venography –



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1. Introduction

Our hospital is a core hospital located in the western part of the Tama Area, which lies within the jurisdiction of Tokyo Prefecture. In October 2008, we reopened following extensive renovations (**Fig. 1**). Although the final opening of the hospital is scheduled for February 2010, the hospital functions are already operating at a level of about 80%. The new hospital, which will have 316 beds at the time of the final opening, plays a part in providing medical care to residents of the local area. At the time of renovation, the Department of Radiology arranged the examination rooms and arranged and selected equipment in consideration of the circulation of patients and staff. This was conducted in accordance with the hospital's philosophy and was based on several years of consideration, reflecting a desire to develop medical care in a way that benefits patients and, in particular, to minimize examination waiting times (i.e., by improving throughput) and to minimize the burden on patients (i.e., by reducing examination times).

Nearly all systems (general radiography systems, radiography/fluoroscopy systems, angiography systems, and mammography systems (scheduled for introduction in 2010)) other than those for CT, MRI, nuclear medicine, and treatment are equipped with FPDs. As general radiography systems, we introduced three standing-position and three supine-position models of Shimadzu Corporation's RADspeed safire (**Fig. 2**). Also, as R/F systems, we introduced two of Shimadzu's SONIALVISION safire II systems (**Fig. 3**), and are fully utilizing them on a daily basis.



Fig. 1 External View of Our Hospital



Fig. 2 Shimadzu RADspeed safire General Radiography System



Fig. 3 Shimadzu SONIALVISION safire II R/F System



2. Reasons for Introducing SONIALVISION safire II

At our hospital, surgical examinations are common and fluoroscopy is often used for long periods. It was therefore desirable to create an environment allowing examinations to be performed with as low a dose as possible. In comparison with other companies' FPD systems, SONIALVISION safire II produces relatively high-quality images with a relatively low dose, and also facilitates greater ease of use with aspects such as adjustment of the SID and changes in the F.O.V. size. Regarding radiography, this system is equipped with a large 17 × 17-inch FPD, and can support urological examinations by producing images of the entire abdominal area. We also conduct lower extremity venography over an extended range. For

this purpose, it was necessary to create an environment allowing the entire lower extremity area to be captured with a single imaging operation and, after long consideration, we decided to use the long-view imaging function (hereafter referred to as “slot radiography”), which is an additional function of SONIALVISION safire II. The main reasons for our choice were the simple operability, the high quality, and the ability to perform serial radiography. We were also impressed by the ease and speed of image processing, and felt that this function could help us create a patient-friendly examination environment. Here, I report on our experiences with this system, centering on lower extremity venography performed with slot radiography. Because of space restrictions, I focus mainly on frontal views.

3. Principle of Slot Radiography

In slot radiography, the X-ray tube and FPD move simultaneously at a constant speed in parallel with the longitudinal axis of the table, and data is acquired. There are two acquisition methods that can be used selectively in accordance with the objective: HS mode (150 mm/sec) prioritizes speed and HQ mode (75 mm/sec) prioritizes image quality. Operation is simple and imaging can be executed simply by pressing three buttons. The same region can be imaged again simply by pressing the [SET] button, a feature that further enhances operability (Fig. 4). The acquired data is sent to a special-purpose side station (work station), where image processing is performed. This consists of the extraction of the effective portion of each frame from the acquired images and the joining of the overlapping parts to produce one long-view image. It takes approximately 15 sec in automatic processing mode following the completion of imaging. Because of the parallel movement of the longitudinal imaging system during data acquisition, X-rays are incident on the subject in an almost perpendicular direction, making it possible to obtain images with little distortion, and which facilitates highly precise measurement (Fig. 5).

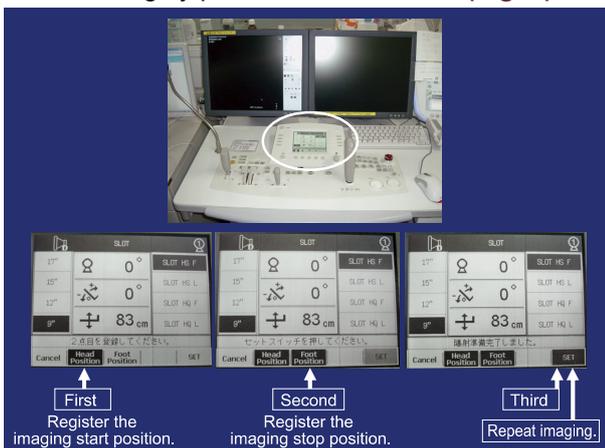


Fig. 4 Slot radiography can be executed simply by pressing three buttons.

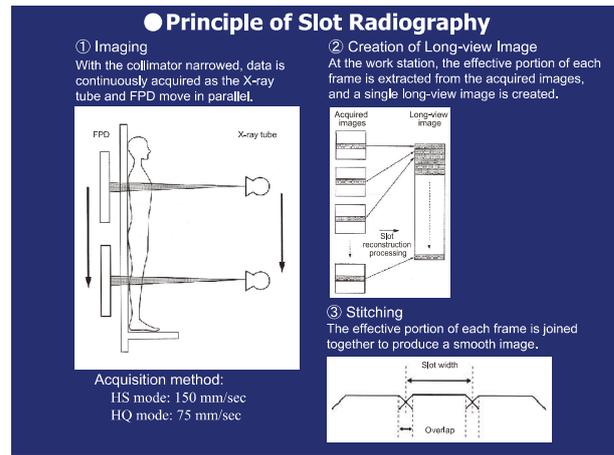


Fig. 5 Principle of Slot Radiography

4. Lower Extremity Venography

Objective: Diagnosis of varicose vein and vein thrombosis in lower extremities

Technique:

- (1) The lower extremity to be examined is warmed for 15 minutes (e.g. gentle heating at 40 °C).
 - (2) The blood supply to the ankle joint was interrupted and a contrast medium is injected via the dorsal venous arch of the foot for 60 sec.
 - (3) After injection is completed, the lower extremity is imaged (early phase and delayed phase) in the standing position with two methods (“ant” and “lat”).
- * Contrast medium: Nonionic iodinated contrast medium
Volume: 50 mL
(Quantity of iodine: 350 to 370 mg)

Varicose veins in lower extremities:

The veins in the lower extremities consist of deep veins, superficial veins, and communicating branches (or “penetrating branches”) that connect them. A “varicose vein” is a superficial vein that has expanded to form a bulge. They mainly occur in the calf area, and form a meandering path over the surface of the skin. There are valves in veins that stop blood flowing backwards, and it is believed that, for some reason, these valves cease to function normally, causing pressure to build up inside a vein, and ultimately producing a bulge when it becomes impossible to withstand this pressure. It is thought that the main causes of varicose veins in daily life include work that involves long periods of standing, childbirth, and aging. It is more common in women.

Deep vein thrombosis:

“Deep vein thrombosis” describes the state that occurs when a thrombus is created for some reason in a deep vein of a lower extremity, causing the flow of blood to stop completely. If a thrombus enters the lungs via a blood vessel, a blood vessel in the lungs may be blocked, and this may lead to a life-threatening condition. This phenomenon has recently become well known as “economy class syndrome”. It is more common in women.

5. Appropriate X-Ray Tube Voltage for Slot Radiography

The lower extremities contain both thick parts, such as the femurs, and thin parts, such as the ankle joints, and in order to create images, it is necessary to use an X-ray tube voltage that is suitable for both extremes. Fig. 6 and Fig. 7 show data based on evaluations of the relationship between thickness (i.e., subject thickness) and X-ray tube voltage using a Burger phantom and R1 micro chart, respectively. It can be seen from this data that the evaluation stabilizes around 100 kV. Also, in visual evaluation that we performed using a “home-made” phantom, evaluation was good around 100 kV (Fig. 8). In evaluation based on different modes (HS and HQ), there did not seem to be any significant difference (Fig. 9). In clinical application, because there is great variety of subject thicknesses, at our hospital, we use the thickness of the center of the femur as a standard for setting exposure conditions.

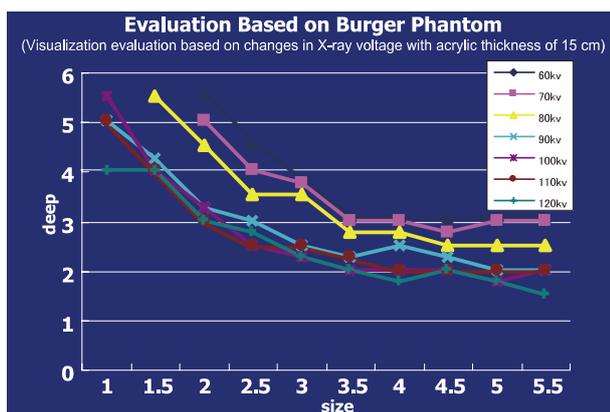


Fig. 6 Results of Visualization Evaluation Based on Changes in X-Ray Voltage with a Burger Phantom

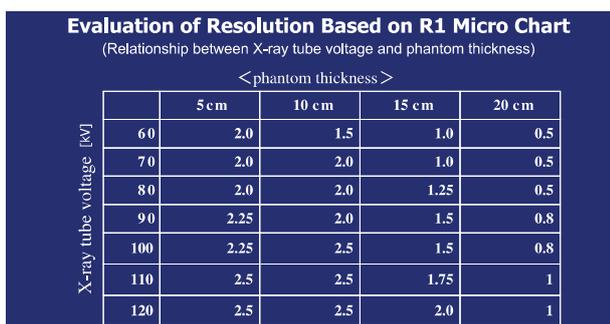


Fig. 7 Results of Evaluation of Relationship Between Subject Thickness and X-Ray Tube Voltage Based on R1 Micro Chart

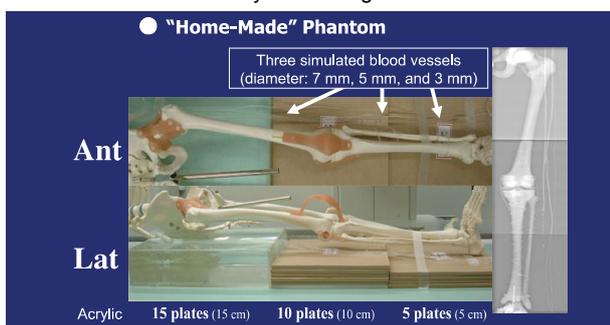


Fig. 8 “Home-Made” Phantom Used for Visual Evaluation

● Image Evaluation Based on Phantom

Comparison of HS (150 mm/sec) and HQ (75 mm/sec) Mode

		HS	HQ
Groin		3.1	3.4
Knee joint		—	—
Ankle joint		3.3	3.6
Femur	Simulated blood vessel (7 mm)	4	4
	Simulated blood vessel (5 mm)	4	4
	Simulated blood vessel (3 mm)	3	3.1
Knee joint	Simulated blood vessel (7 mm)	—	—
	Simulated blood vessel (5 mm)	—	—
	Simulated blood vessel (3 mm)	—	—
Lower leg	Simulated blood vessel (7 mm)	3.6	4
	Simulated blood vessel (5 mm)	4	4
	Simulated blood vessel (3 mm)	3.6	4

Significant difference (-)

Fig. 9 Results of Visual Evaluation for Different Imaging Modes Based on “Home-Made” Phantom

6. Image Processing for Slot Radiography

We considered “G” (gamma correction curve) with respect to image processing. This system has three types of image processing curve for slot radiography. In evaluation based on the “home-made” phantom, it was established that the G2 curve shown in Fig. 10 was optimal.

The thickness of lower extremities can exceed 20 cm in thick parts and be less than 5 cm in thin parts. In order to maintain good image quality for both extremes of thickness, it is essential to select a gamma curve that is relatively flat overall. The G2 curve has a relatively low inclination at intermediate levels, and ensures image processing that facilitates easy observation from low-concentration areas to high-concentration areas. It cannot be denied, however, that because of its relative flatness, the contrast is somewhat insufficient for the shadows of fine blood vessels. This problem can be solved using “E” (edge enhancement) processing. Enhancing the outline of shadows makes them easier to observe. Although we have not conducted a comprehensive investigation of this aspect, we use a setting of E3 (“quite strong”) at our hospital.

In a physical evaluation of image quality based on differences in mode, HQ mode was found to be slightly better. In clinical evaluation, however, there did not seem to be any significant difference. Regarding the image evaluation of slot radiography, because the imaging system is moving, there is some degree of blurring. It is conjectured that this blurring is the reason why there is not much difference in image quality between the various sets of data.

There are also imaging parameters such as AWC and DRC. We did not, however, conduct an investigation of these parameters on this occasion and so I will not comment on their relevance.

● Visual Evaluation of "G" (Evaluation Based on "Home-Made" Phantom)

	G1	G2	G3	
Groin	3.1	3.4	2.2	
Knee joint	—	—	—	
Ankle joint	3.3	3.6	3.3	
Femur	Simulated blood vessel (7 mm)	4	4	2.2
	Simulated blood vessel (5 mm)	4	4	3.3
	Simulated blood vessel (3 mm)	3	3.1	3.3
Knee joint	Simulated blood vessel (7 mm)	—	—	—
	Simulated blood vessel (5 mm)	—	—	—
	Simulated blood vessel (3 mm)	—	—	—
Lower leg	Simulated blood vessel (7 mm)	3.6	4	4
	Simulated blood vessel (5 mm)	4	4	3.5
	Simulated blood vessel (3 mm)	3.6	4	3.5

Points: 4: Very good 3: Good 2: Poor 1: Very poor

Fig. 10 Results of Visual Evaluation for "G" (Gamma Correction Curve) Based on "Home-Made" Phantom

7. Comparison with Conventional Examination Methods

In conventional lower extremity venography, four long-view cassettes were used with an F/S system. Because the examination was performed on the floor, no significant burdens were observed with respect to changes of the patient's posture. In examinations performed with slot radiography, however, because of the movement of the X-ray tube and FPD, there are restrictions on the position of the patient, and the footstool must be set at quite a high position. This puts quite a large burden on the patient and is the only disadvantage of this system. Great care is required when changing the posture of the patient on the footstool, which is approximately 30 cm square. HS mode, which prioritizes time, is used in consideration of the influence of movement.

Regarding image processing, films obtained with the conventional method had to be developed in a dark room, which took approximately 15 minutes. With this system, however, image processing is performed quickly on the work station. I feel that this is a great advantage. Regarding dose, slot radiography is possible with a smaller dose than that required with the conventional method did (**Fig. 11**).

Because of the significant reduction in image processing time, it has been possible to reduce the overall examination time by about 20% to 30%.

Actual slot radiography images obtained in lower extremity venography are shown in **Fig. 12**.

Comparison with Conventional Method (F/S)	
Examination posture	Conventional method : Examination performed with extended system in general radiography room, allowing it to be performed on the floor, and making it easy to change posture. Slot radiography : Examination performed at height of 70 cm above floor, making posture changes more difficult, and increasing the burden on the patient.
Exposure method	Conventional method : Long film replaced in dark room. Entire lower extremity area exposed simultaneously. Slot radiography : No film replacement necessary. Exposure takes place while system moves.
Image processing	Conventional method : Approx. 15 minutes required to develop images after exposure. Slot radiography : Approx. 2 minutes required for image processing (for 4-way exposure).
Dose	Conventional method : 220 (mGy) Slot radiography : 96.1 (mGy)
Examination time	Conventional method : 30 minutes Slot radiography : 20 minutes

Fig. 11 Comparison of Slot Radiography and Conventional Method (F/S System)



Fig. 12 Slot Radiography Images Obtained in Lower Extremity Venography (Early Phase, Frontal, and Lateral Images)

8. Points to Note in Slot Radiography

As mentioned before, slot radiography involves the execution of imaging during movement of the system. For this reason, the acquired data incorporates an element of imprecision corresponding to this movement. For example, when observing a trabecula of bone in bone radiography, it must be kept in mind that the image quality is different to that obtained with still images. In fact, when we first introduced slot radiography at our hospital, although we considered its application to imaging of the femur, we did not reach the point of using it to visualize a trabecula of bone. There are some ways, however, in which image quality can be improved, and I would like to make a report about them on some other occasion.

Although slot radiography is mainly used for imaging of the entire spine or the entire lower extremity area, in an age when CT is used for whole-body imaging in trauma cases, it is conjectured that, in consideration of the dose, it may be worth investigating the possibility of using slot radiography for whole-body bone imaging. In the future, I expect to come across reports of a diverse range of applications.

9. Summary

Here, I have described our experiences of using the slot radiography function of the SONIALVISION safire II R/F system for lower extremity venography. Despite the disadvantage of having to set the footstool in a high position in order to perform examinations, it is an extremely useful function, which allows imaging over a large range in a single operation, makes it possible to produce seamless, distortion-free images with simple operations, and offers easy operability in image processing.

The substance of this report was presented at the 65th Annual Scientific Congress of the Japanese Society of Radiological Technology (JSRT).

Finally, I would like to thank Mr. Arai and Mr. Karukaya of Yamamoto Shokai for presenting me with this opportunity.

References

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