

# Using the SONIALVISION G4 for Orthopedics

## – Utility of the SLOT Advance Application –

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### 1. Introduction

#### • Overview of Hospital

The Sanraku Hospital (270 beds, including 243 general ward beds and 27 psychiatric ward beds) is located 3 minutes' walk from Ochanomizu station in the metropolitan Tokyo. The name "Sanraku" is from a quote by Mencius, the Confucian philosopher, meaning "three joys."

To commemorate the 40th anniversary of the 1890 Imperial Rescript on Education in 1930, the Tokyo Prefecture Education Employee Mutual Aid Society established the hospital in 1933 to serve educators in Tokyo. Then in 1988, it was designated as a medical institution authorized to treat patients with Japanese health insurance coverage and changed to a general hospital. The hospital remains dedicated, as before, to supporting the health and treating diseases of active public educators in Tokyo prefecture and their families. It also provides healthcare to general citizens, including retired educators.



Fig. 1 Sanraku Hospital

#### • Increase of Spine Patients

Since 1986, the primary field of specialization for the orthopedic department at our hospital has been spine and spinal cord disorders. Consequently, we have performed many spinal instrumentation surgeries using titanium screws and hooks to correct spinal deformities and treat instability. For simpler cases

of herniated lumbar discs or spinal canal stenosis that do not involve deformities, we provide spinal disease care, such as decompression using a small incision or minimally invasive surgery. With the aging population in recent years, there has been a sharp increase in the number of spinal canal stenosis cases that involve spinal deformities, such as scoliosis, lordosis, kyphosis, and spondylolisthesis, and cases of osteoporotic vertebral compression and burst fractures. In many cases, the patients that come to our hospital have a severe spinal deformity or spinal cord compression considered too difficult to treat at other hospitals. In order to provide prompt and appropriate treatment to the increasing number of patients with spinal disorders, we opened a new Spine/Spinal Cord Center in 2011.



Fig. 2 Hospital Entrance

### 2. Background of Introducing the System

Our hospital operates three fluoroscopy systems, of which two were image intensifier models used exclusively for screenings. However, one of these two was due for replacement.

Until now, the one fluoroscopy system with a flat panel detector (FPD) installed in a separate room has been operated at full capacity for slot radiography of the entire spine or entire lower extremities, myelography and discography examinations, and tomosynthesis (tomography) for orthopedics, and ERCP and PTCO procedures, post-operative follow-up, and other gastrointestinal examinations. However, with only one room, in many situations it was difficult to accommodate multiple examinations that

occurred at the same time. Therefore, to solve that difficulty as well, we began needing a way to perform multiple examinations concurrently. In terms of installation space, the screening room with the fluoroscopy system was already crowded. In order to utilize the room more efficiently so that both hospital staffs and the patient can move safely and smoothly with minimum burden placed on them during the examination and to perform examinations, we wanted to minimize the size of cabinets and so on. In addition, we wanted an FPD fluoroscopy system that would allow performing the slot radiography required for orthopedics, which is the main focus of our hospital. Therefore, due to the reasons and difficulties indicated above, we requested the following expandability for the replacement system.

1. Flat panel detector (FPD) fluoroscopy system capable of slot radiography
2. Capable of low dose fluoroscopy and radiography
3. Improved image processing technology
4. Capable of being installed in a cramped examination room
5. Obtaining more working space in the examination room
6. Offers additional functionality besides fluoroscopy examinations

There were several FPD fluoroscopy systems available for the given introduction schedule, but the SUREngine Advance image processor was capable of low-dose gastrointestinal imaging and image processing. In terms of slot radiography,



Fig. 3 Control Room



Fig. 4 Examination Room

which was a major criterion, the system had to be able to reliably provide frontal and lateral full spine images and full lower extremity (frontal) images, even for cases that may be difficult for image processing due to differences in body sizes. In addition, standing, supine, and even standing with the head downward positions must be selectable for radiography. Consequently, we selected the SONIALVISION G4 system from Shimadzu Corporation ("G4" below) (Fig. 3 and 4).

### 3. Full-Length Radiography of the Spine and Lower Extremities

#### • Current Status

The G4 system was installed in September 2013, and started to be used with SLOT Advance in December. Currently we perform half of our full spine examinations using the G4 (Table 1). It is normally performed in the standing position at our hospital. For patients for whom the standing position is not possible, radiography is performed in a half-tilted or supine position. The SID is selectable on the G4 from 110, 120, or 150 cm, but due to the height of the examination room ceiling and the structure of the G4 system, to prevent any accident, and also to provide consistency for comparing images, we perform exposures at a SID of 110 cm.

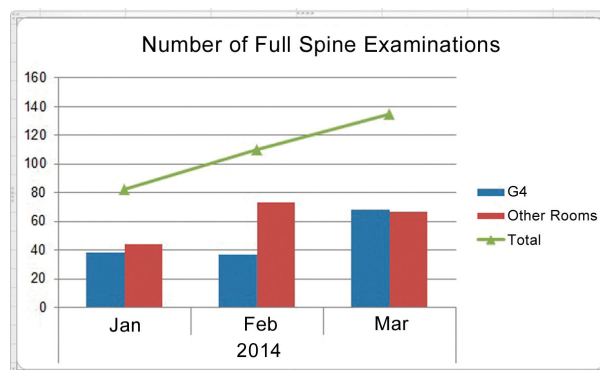
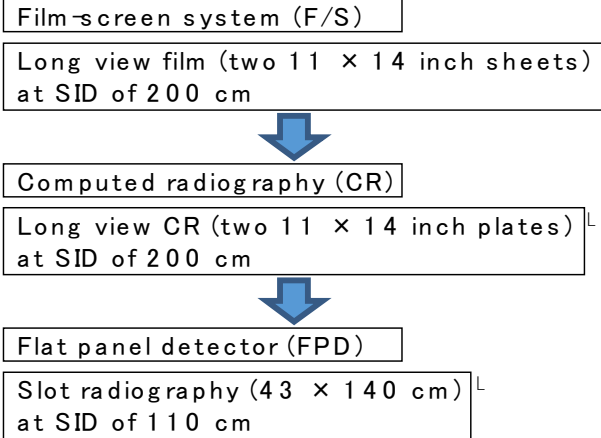


Table 1 Data for Recent Three Months

#### • Full Spine (Fig. 5 and 6)

Previously, the radiography standards for orthopedics at our hospital specified obtaining images extending from the cervical spine to hip joints in two orientations, frontal (AP) and lateral (L-lat). However, it was not always possible to cover that area entirely in the past cases. However, introducing slot radiography allowed us to cover a large area. Consequently, our standards for full spine images were changed to include the range from the base of the skull on the head end to include the knee joints on the feet end (with left and right femur heads aligned).

## \*Imaging System, Imaging Range, and SID



## \* Examination Orders

- Full spine: 2 directions (frontal and lateral)  
Additionally:
- Frontal (AP): Left and right lateroflexion
- Lateral (lat): Anteflexion and retroflexion  
Provided frontal images are acquired in A-to-P direction and displayed in P-to-A direction (for checking in surgery position) and lateral images LR-lat (same display as CT and MR)



Fig. 5 Frontal and Lateral Full Spine Image (Before Surgery)



Fig. 6 Frontal and Lateral Full Spine Image (After Surgery)

## \* X-ray Conditions

(Slot HQ mode)

- Frontal  
Tube voltage: 80 to 95 kV;  
Tube current: 400 to 500 mA  
Acquisition: 5 to 8 msec; SID: 110 cm
- Lateral  
Tube voltage: 80 to 100 kV;  
Tube current: 400 to 500 mA  
Acquisition: 5 to 8 msec; SID: 110 cm

These images of the upper thoracic spine, which is a difficult area to see, were obtained after surgery, but image processing can be used with the same slot radiography data to combine the target areas and improve visibility, without repeating exposures (Fig. 7 and 8).



Fig. 7 Thoracic Spine Case

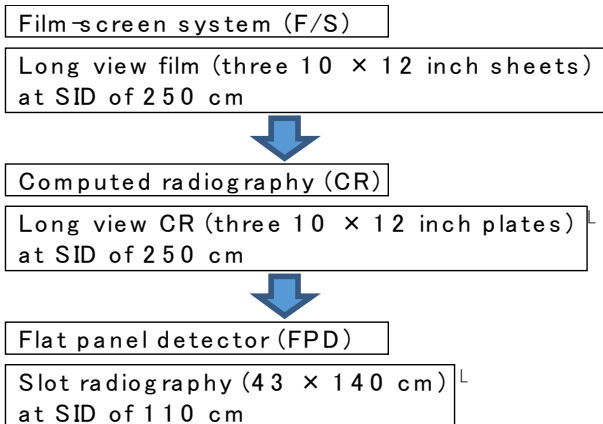


Fig. 8 Enlarged View

## • Full Lower Extremities (Fig. 9)

Previous standards of the imaging range for full leg imaging was from somewhat above the iliac crest to the ankle and had to examine separately for the left and right legs. However, the introduction of slot radiography now allows obtaining both legs image at once, which improves its utility for left-right comparisons.

## \* Imaging System, Imaging Range, and SID



## \* Examination Orders

- Full length lower extremities: One direction (frontal)

## \* X-ray Conditions

- (Slot HQ mode)
- Frontal
    - Tube voltage: 80 to 95 kV
    - Tube current: 400 mA
    - Acquisition: 5 to 8 msec
    - SID: 110 cm

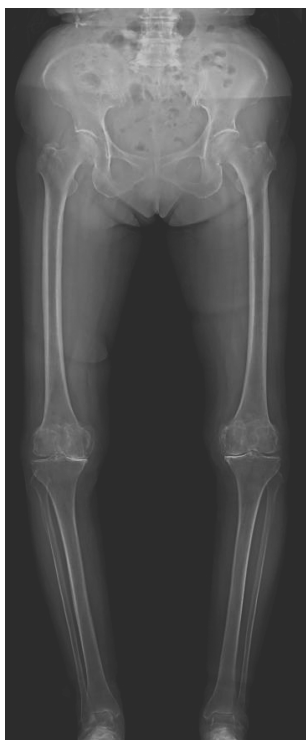


Fig. 9 Frontal Full Lower Extremity Image

Previously, both film and CR imaging caused relatively high patient exposure dose levels and also required longer exposure and image processing times, which caused an additional stress on patients. However, introducing slot radiography with a 17-inch FPD reduced patient exposure dose levels and shortened both exposure and image processing times, which have been beneficial to the patient.

## 4. Advantages of SLOT Advance

### \* Advantages of Slot Radiography

Slot radiography allows capturing slit shaped images as the X-ray tube and FPD move at a constant speed in the direction of the body axis (Fig. 10). Advantages of slot radiography include minimal image distortion and the ability to obtain reconstructed images with no discontinuities.

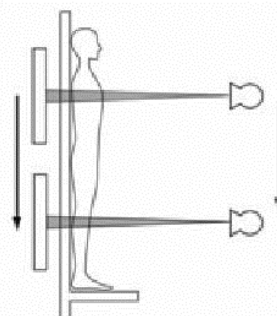


Fig. 10 Diagram of Slot Radiography

### \* Advantages for the Patient

Lower exposure dose levels and shorter examination times reduce the discomfort and stress of having to hold awkward positions.

### \* Advantages for the Technologist

Patients can be positioned more easily. It makes it very easy to register the imaging range using the irradiation lamps in the examination room. (Fig. 11 and 12).

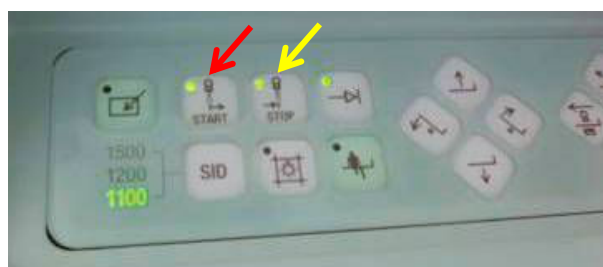


Fig. 11 Control Panel on R/F Table



Fig. 12 Patient Positioning Using the Irradiation Lamp (Left: Above skull base; Right: Knee joints)

- Using SLOT Advance for full spine or full lower-extremity radiography switches the control console monitor to the slot radiography mode, which prevents exposure errors.



**Fig. 13** During Regular Radiography



**Fig. 14** During Slot Radiography

After exposures, images are automatically integrated and displayed in about 10 seconds. Then SUREngine Advance image processing starts automatically and displays the image 5 seconds later. During that process, the next radiography mode can be specified and the patient repositioned.

### \* Advantages for the Hospital

Full spine imaging standards (from skull base to knee joints) and full lower extremity standards (from somewhat above the iliac crest to the ankle) can now be achieved comprehensively. Images necessary for treatment can be obtained almost instantaneously by SUREngine Advance automatic image processing, contributing to quickly providing accurate images.

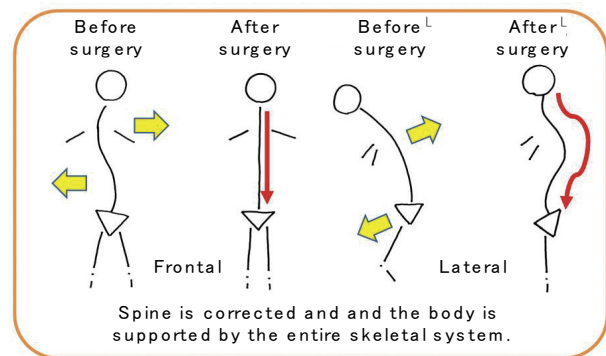
## 5. Difficult Lateral Images

Our hospital requires obtaining full spine images in two directions, as mentioned above. Typical applications include pre- and post-spinal instrumentation surgery imaging, scoliosis, and so on. For such cases, the frontal and lateral images are used to view the status of spinal scoliosis, lordosis, or kyphosis, as well as the positions, left-right differences, and the anteroposterior relationships of the pelvis, hip joints, and knee joints.

Lateral images are even used to view changes in the degree of anterior spinal inclination before and after surgery or corrections due to treatment. Recently, there has been an increase in spinal corrective surgeries performed to improve patient quality of life (QOL). Therefore, simulation conferences are conducted at our hospital to select the best possible technique (by using the so-called Sanraku Formula)<sup>1) 2)</sup>, so that, after surgery, the body is supported by the entire skeletal system, rather than only by the spine. To achieve this, we try

changing the spine-pelvis angle and lifting the pelvis while also checking the hip and knee joint angles and also consider if deformation at a part can be compensated by functions of other parts. For this purpose, it is very important to supply accurate and reliable lateral images that extend from the cervical spine to the sacral spine.

Other manufacturers also offer stitching radiography systems for frontal full spine and frontal full lower extremity imaging that are adequate for diagnostic purposes, but based on our experience using the G4 at our hospital for orthopedics, and also for diagnostics and treatment in other departments, the G4 offers far superior utility than other models currently available, in terms of lateral images of the entire spine and image processing capabilities.



**Fig. 15** Illustrations of Spine Corrections Before and After Surgery (Examples)

## 6. Summary

Based on our experience using the G4 in the orthopedic surgery department, it offers the following advantages.

- SLOT Advance**  
Slot radiography offers less image distortion and no discontinuities among stitched images. After exposure, slit images are integrated together in only 10 seconds.  
When slot radiography mode is selected, the display on the control console switches to the slot radiography mode to allow visually checking the settings and prevent exposure errors.
- SUREngine Advance**  
Within a few seconds after stitching images, SUREngine Advance processes the image so that it can be viewed almost instantaneously. It also allows transitioning immediately to the next exposure, which shortens examination times and improves efficiency.
- FPD slot radiography** covers a larger exposure area than long view radiography using a film-screen (F/S) system or computed radiography (CR) and it offers significantly lower exposure dose levels. Consequently, patient exposure levels are lower

and invasion to the body during examination is reduced.

- It can render full spine images with differing X-ray absorption levels due to differences in body thickness (for the spine from neck to tailbone and also from the hip joints to knee joints) in both frontal and lateral views. Similarly, it can even display frontal images of the full lower extremities (from hip joints and knees to ankles). It can supply lateral full spine images that offer high diagnostic utility.

Based on our experience using the G4 in the orthopedic department for full spine and full lower extremity regions, as described above, the SLOT Advance application has proven to be extremely useful.

Therefore, in other hospitals as well, SLOT Advance shall be very effective in orthopedic full spine or full leg examinations.

## 7. Conclusion

SLOT Advance enables fast and appropriate image processing for full spine and full lower extremity radiography. We are very grateful to Shimadzu Corporation for developing this technology and look forward to further developments in the future. As radiotherapy technologists in a society that has become extremely concerned about radiation exposure, we should strive diligently to cooperate with other institutions in an effort to minimize exposure levels to patients, reduce the stress on patients that examination can cause, and supply images that are firstly safe and also diagnostically useful.

### References

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