MEDICAL NOW Digest

No.84 2018

SHIMADZU

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This booklet is a digest version of MEDICAL NOW No. 84 (Published in August 2018), which is issued for Japanese medical professionals.

Vascular

Flex-APS (Flexible Active Pixel Shift) Real Time Auto Pixel Shift for interventional neurology

Shun Sato, M.D.

Department of Neurological Surgery, Nippon Medical School
Department of Neurological Surgery, Hakujikai Memorial Hospital
Shun Sato

1. Introduction

It has been 6 months since Hakujikai Memorial Hospital obtained a new Trinias application on a trial basis that assists interventional neurology. This article describes the utility and practicality of this application.

2. Advantages and Disadvantages of Digital Subtraction Angiography

Digital subtraction angiography (DSA) is an imaging method used widely with angiography systems for interventional neurology. DSA allows observation of vessel information isolated from other anatomical structures by acquiring a mask image before injecting contrast media, then subtracting this mask image from live images acquired during contrast media injection. DSA has the advantages of low contrast resolution and spatial resolution, but also the shortcoming of susceptibility to patient movement. Patient movement between mask image and live image causes misregistration artifacts that can hinder a correct diagnosis.

Recently, an increasing number of cases of interventional neurology, including therapeutic procedures, are being performed under local anesthesia. Although these patient's head is retained firmly and the patient is asked to remain motionless before acquisition in these cases, it is not uncommon for the head to move slightly due to respiratory fluctuation or from the heat sensation and pain associated with injection of contrast media, which leads to misregistration artifacts.

3. Conventional Method of Artifact Correction (Pixel Shift Processing)

Pixel shift processing is a commonly used method for correction of misregistration artifacts. Pixel shift processing eliminates misregistration artifacts from DSA images by performing a linear transformation of the mask image using parallel displacement, rotation, enlargement, shrinkage, etc. of the image to compensate for body movement occurring between mask image and live image acquisition. However, due to the linear nature of the correction performed by pixel shift processing, image correction is sometimes inadequate when there is movement in only part of the image, or when body movement causes twisting in the image. Pixel shift processing has also disrupted a smooth workflow when image correction must be revised by performing frame-by-frame postprocessing to account for different movement between frames, and because checking against a reference in real time can only be performed with images that have not undergone pixel shift processing.

4. Artifact Correction by Flex-APS

Flexible Active Pixel Shift (Flex-APS) is an application that resolves the shortcoming of pixel shift processing mentioned above. Flex-APS is able to correct for twisting or partial movement of the body by determining motion vectors for every pixel in all frames of live images relative to the mask image **(Fig. 1)**, and subtracting the mask image after nonlinear transformation of the mask image based on these vectors **(Fig. 2)**. This allows acquisition of fully corrected DSA images even during body movement that conventional pixel shift processing is unable to correct for. Also, since this correction is performed in real time, all

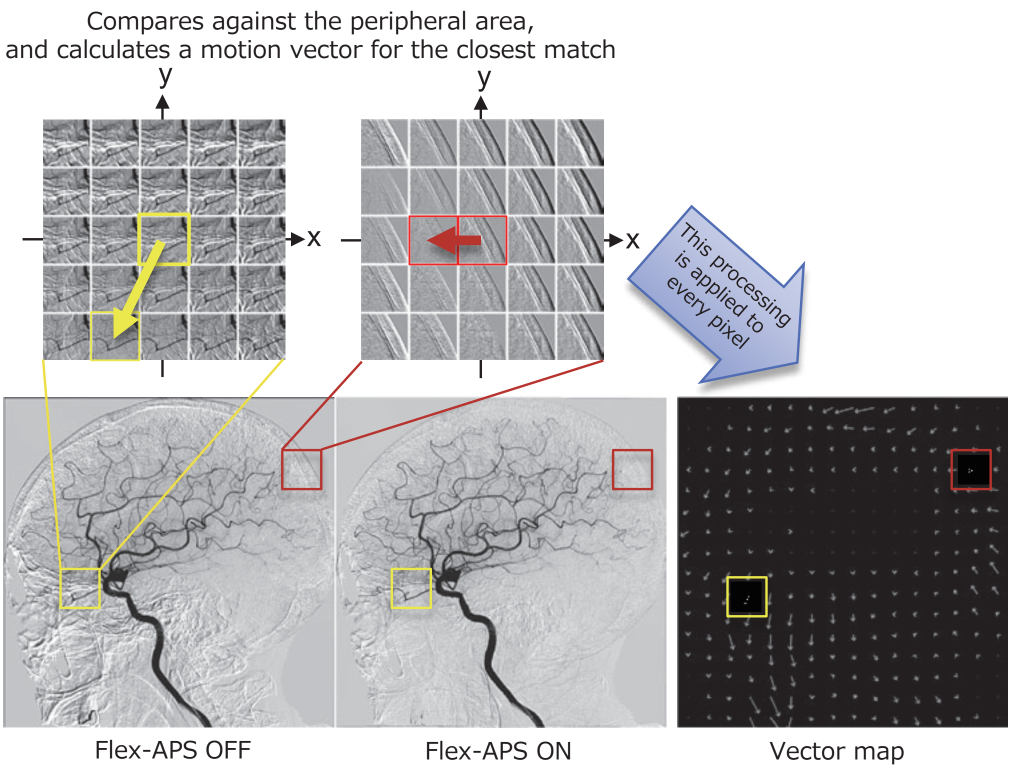


Fig.1 Motion Vector Calculation by Flex-APS

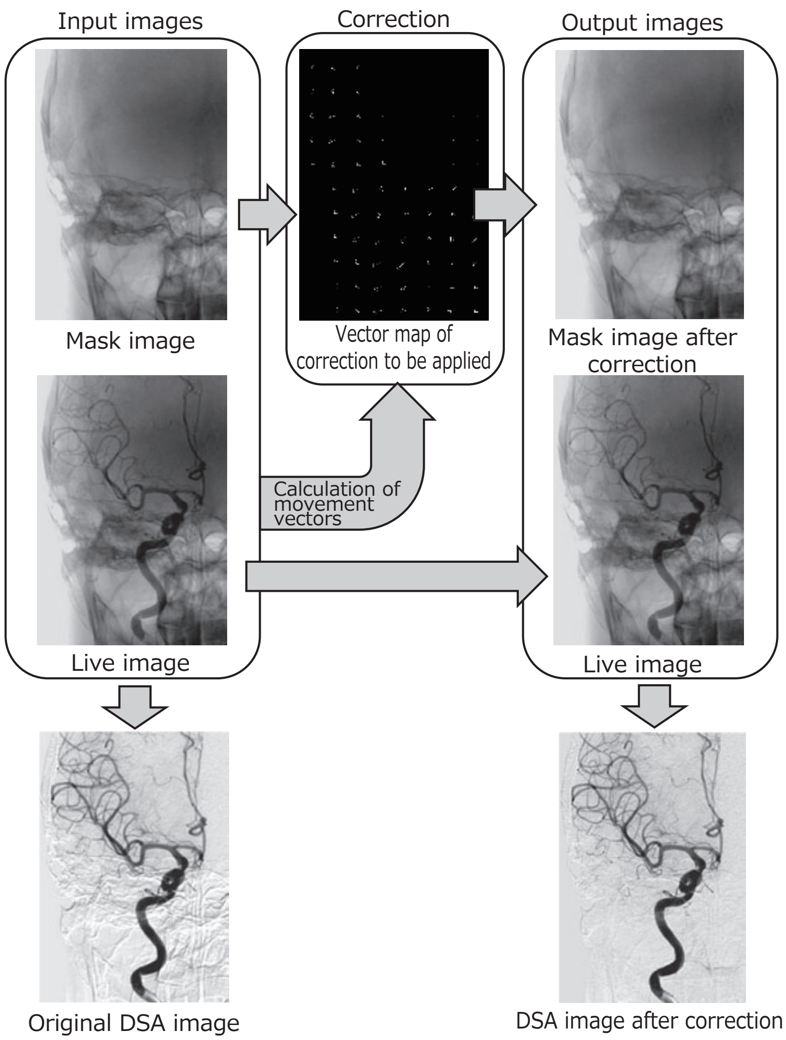


Fig.2 Process of Correction by Flex-APS

frames displayed during imaging are DSA images corrected by Flex-APS. This application gives effective artifact reduction, so is best suited to interventional neurology performed under local anesthesia.

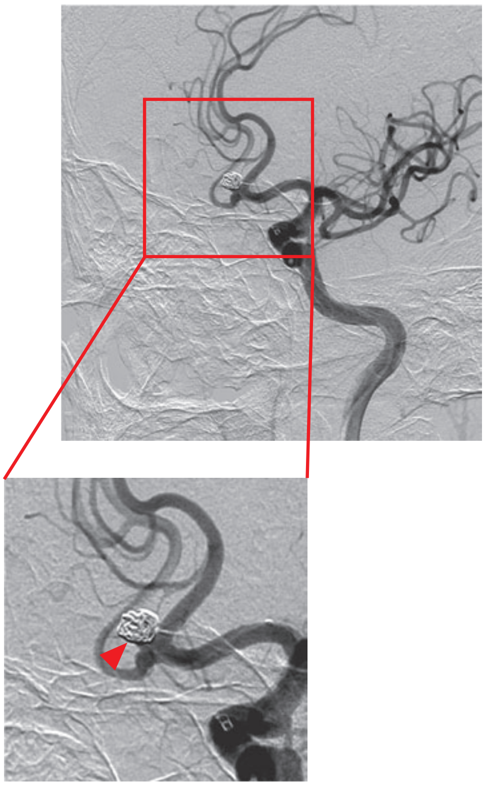
5. Clinical Utilization of Flex-APS

Since introducing Flex-APS, all interventional neurology are now performed under local anesthesia as we are better equipped to deal with a certain degree of patient movement. Even under general anesthesia, respiratory fluctuation is visible after 4.5-inch magnification and a vessel roadmap cannot be used for an extended period of time. Although using local anesthesia further shortens this period of time, it allowed the procedure to be performed without stress. Furthermore, since Flex-APS performs pixel shift processing in real time, it has the distinct benefit of producing clear live images and reference images, which improves 2D visibility.

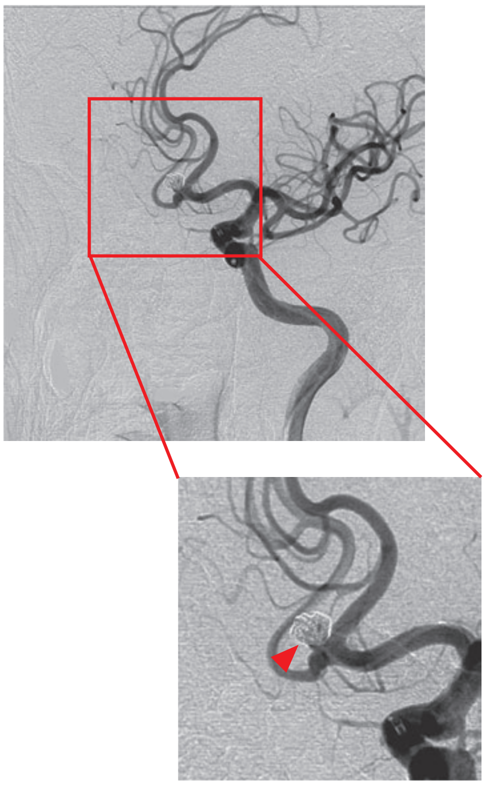
With regard to intracranial stenting, though the visibility of perforating branches has improved since introducing Flex-APS, the time being taken to determine positioning for intracranial stenting has in fact increased. This increase is attributed to previously indistinguishable vessels now becoming visible and giving us more to contend with during procedures. However, this increase has also coincided with an increase in procedure safety and prevented postoperative strokes.

Flex-APS has also been very useful during aneurysm coiling as the pixel shift processing also works on the coil mass. There were times at the end of coiling when we were unsure whether the image contained an artifact or contrast media had flowed into the margin of the aneurysm. This type of situation has decreased greatly since introducing Flex-APS **(Fig. 3)**. A characteristic feature of Flex-APS is that high signal intensity metals are matched with high accuracy by pixel shift processing. This allows us to perform pixel shift processing of the coil mass and obtain a clear view of the flow of contrast fluid into the aneurysm or into surrounding vessels. The result has been a higher percentage of coil packing compared to before introducing Flex-APS.

This pixel shift processing is also applied in a similar manner for stents during carotid artery stenosis (CAS) procedures, and produces clearer images that also increase patient satisfaction when observed as postoperative images.



Flex-APS OFF



Flex-APS ON

Fig.3 Example Use of Flex-APS (During Coiling)

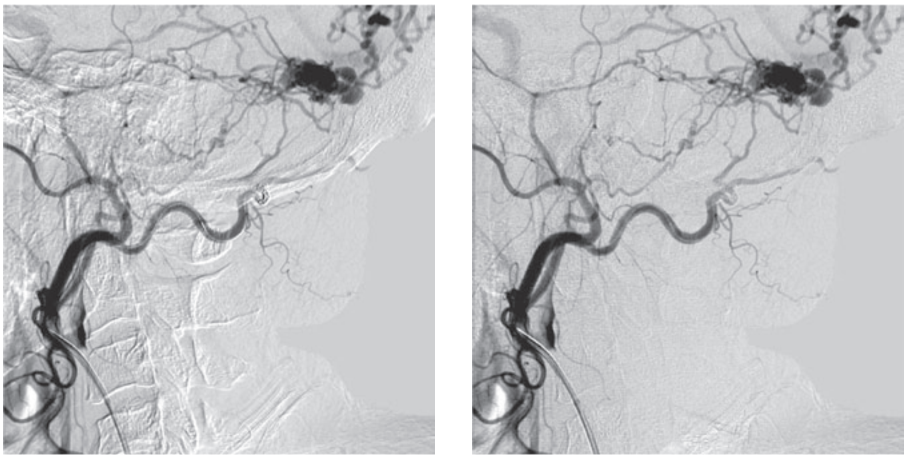


Fig.4 Example Use of Flex-APS (During dAVF)

This approach is also used during arteriovenous malformation (AVM) and dural arteriovenous fistula (dAVF) procedures, and has resulted in clearer depiction of arterioles and penetrating branches, while pixel shift processing of the coil has made microcatheter manipulation easier **(Fig. 4)**.

6. Future Utilization of Flex-APS in interventional neurology

Although craniotomy-based procedures currently exist for all brain disorders, endovascular therapy is being undertaken as an alternative approach to cerebrovascular diseases. To ensure differentiation of endovascular therapy from craniotomy-based procedures, we need to focus on the advantages afforded by endovascular therapy being a minimally invasive procedure. These advantages must be used to benefit patients by use of local anesthesia and shorter hospitalization times. Due to the ability to accommodate in real time for small body movements that occur during local anesthesia and produce clearer images, Flex-APS promises to become an essential application that will lead to improved procedures.

Vascular

Interventional Radiology of the Abdomen Using Trinias Applications

Yushi Araki, M.D.

Department of Radiology, Kumamoto Rousai Hospital

Yushi Araki

1. Introduction

Kumamoto Rousai Hospital is located in Yatsushiro, the second largest city in Kumamoto Prefecture. As a core hospital of the southern region of Kumamoto Prefecture, the hospital provides comprehensive medical care and operates as a core hospital for acute phase care and as a disaster base hospital. As a center for supporting achievement of both treatment and work, Kumamoto Rousai Hospital also plays a role in contributing to working practice reforms promoted by the Japanese government. The emergency room, ICU, and helipad were also upgraded during a recent hospital renovation to improve emergency medical systems and disaster medical services.

The hospital has two angiography rooms to meet the needs of emergency medicine, which are equipped for procedures related to acute myocardial infarction and a variety of other cardiovascular diseases, such as percutaneous coronary intervention (PCI), endovascular treatment (EVT), and ablation. The hospital also utilizes angiography systems (all from Shimadzu Corporation) for tasks that include radiological contrast procedures/IVR and neurosurgical contrast investigations/IVR (cerebral aneurysm coil placement, etc.). Among these systems, the Trinias C12 system obtained by the hospital in February 2018 not only provides excellent fluoroscopic image quality in its basic specification, but the quality of procedures it supports has also been improved by using accessory applications. In this article, I will briefly describe the functions of Trinias while presenting cases of IVR of the abdomen.

2. Main Trinias Applications Effective for abdominal intervention

(1) Rotational DA (Digital Angiography/SCORE 3D)
(2) RSM-DSA (Digital Subtraction Angiography/ SCORE RSM)
(3) Cone Beam CT (SCORE CT)

(1) Rotational DA (SCORE 3D) (Fig. 1)

With digital subtraction angiography (DSA), we have seen cases of poor separation between vessel branches among abdominal vessels, and in particular among hepatic arteries when only frontal images were used. For scheduled IVR procedures such as transcatheter arterial chemoembolization (TACE) for the treatment of hepatocellular carcinoma (HCC), a procedure plan is created based on information obtained by CT angiography performed before

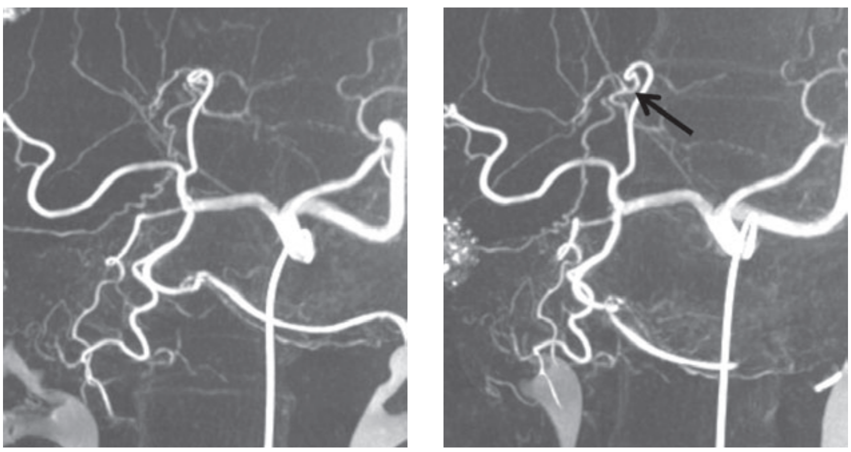


Fig.1 Celiac Artery : by Rotational DA (MIP Processing)
Although there is poor separation at the origin of branches of the left hepatic artery, good separation is obtained by LAO15°/CRA15° (arrow).

surgery. However, when frontal DSA images are used as a mapping during procedure, it can sometimes be difficult to perform selective angiography and implement procedures due to excessive overlapping and poor separation between hepatic arterial branches. Performing repeated DSA acquisitions while searching excursively for an oblique angle that allows branch vessel selection increases the X-ray dose during procedure by the number of acquisitions performed.

When performing rotational DA (digital angiography/ SCORE 3D), the acquired three-dimensional data is stored on a 3D workstation where 3D images are created. If more detailed work is required, the data can also be sent to other workstations in the hospital. 3D images created at the appropriate angle are sent to be displayed by the monitor on the angiography system. Information about the oblique angle used in the 3D image sent to the monitor can also be sent to the angiography system itself to allow immediate and synchronized movement of the C-arm into the appropriate position. This allows procedures to be performed efficiently.

(2) RSM-DSA (SCORE RSM) (Fig. 2)

With RSM-DSA, a low-frequency mask image is created from data acquired during injection of contrast media, which is then subtracted in real time (RSM: Real-time smoothed mask) to obtain a relatively enhanced image of the vessels. Although RSM-DSA is considered slightly inferior to DSA in some areas, such as image contrast and evaluation of tumor staining in particular, it is effective in cases not suited to DSA due to body movement or emergency cases that are unable to suspend breathing, and can be considered a necessity for IVR procedures performed in emergency cases.

Furthermore, using RSM-DSA that utilizes precessional movement of the C-arm allows the discovery of angles that have few overlapping arterial branches, and transmitting this angular data to the C-arm, as described above for rotational DA, allows for speedy implementation of the next procedure.

(3) Cone Beam CT (SCORE CT) (Fig. 3)

TACE for the treatment of HCC is a procedure that involves identifying the feeding arteries of the tumor to be treated, inserting a microcatheter near the tumor, and injecting antitumor agents or obstructing material. However, due to complex hemodynamics, HCC can be supplied with blood by multiple arteries or receive blood flow from non-hepatic arteries (extrahepatic blood supply arteries).

CT like imaging that uses the latest cone beam CT (SCORE CT) is considered useful for perioperative decision-making in cases that make feeding vessel identification difficult. After a hepatic arterial branch is selected with a microcatheter, falsely identified feeding vessels can be identified just before drug injection by injecting dilute contrast media while performing cone beam CT. When the results of angiography (Rotational DA, DSA, Cone beam CT) performed just before performing TACE do not agree with results from CT angiography performed before a procedure, complications such as abscess formation from ischemia associated with unwanted arterial embolism can be avoided by choosing a two-stage procedure that takes into account the possibility of an extrahepatic blood supply.

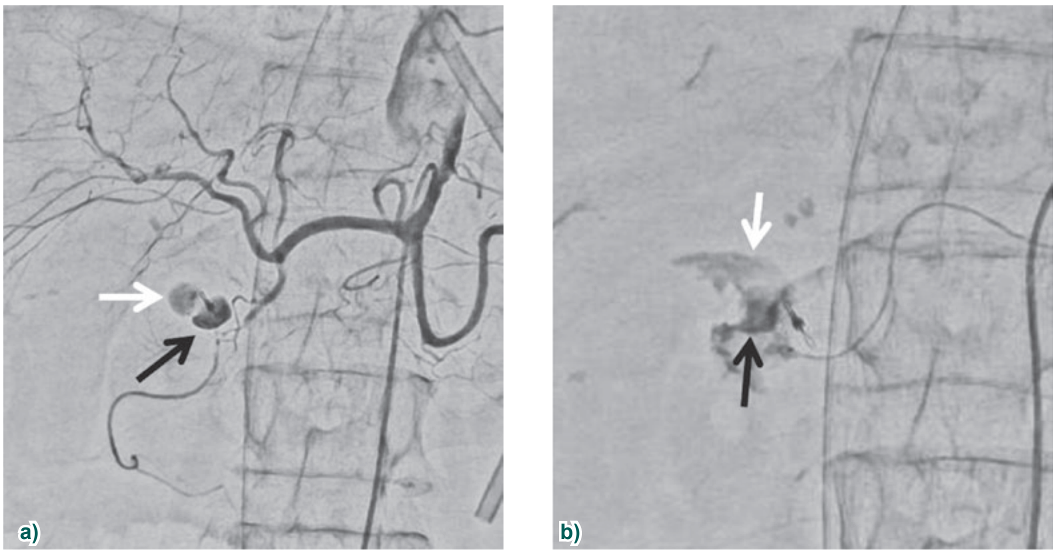


Fig.2 Celiac Arterial : by RSM-DSA (SCORE RSM)
a) Pseudo aneurysm found in duodenal branch of gastroduodenal artery (black arrow)
b) Extravasation and pseudo aneurysm observed at bleeding vessel (white arrow)

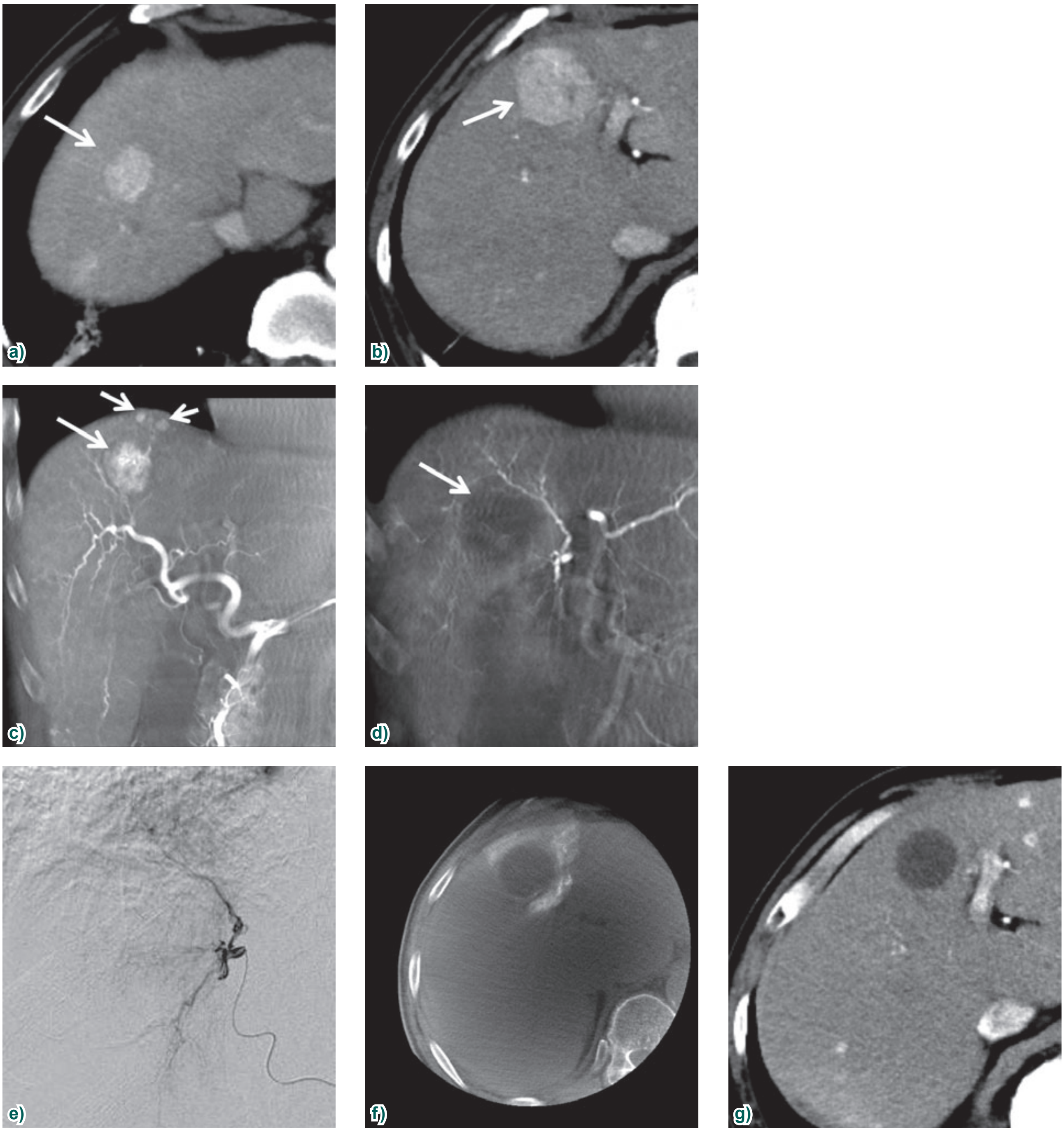


Fig.3 Cone Beam CT (SCORE CT) Used Successfully in HCC Case
a), b) CT before TACE: Early phase staining of HCC observed in S8 of right hepatic lobe and S4 of left hepatic lobe (arrows)
c), d) Rotational DA (Slab MIP image): Shows staining of S8 HCC that uses right hepatic artery anterior segment branch as feeding artery, and daughter nodules (arrows)
No feeding vessel or tumor staining observed for S4 HCC (arrow)
e) DSA of middle hepatic artery (A4): Feeding vessel for S4 HCC not found
f) Cone beam CT (SCORE CT): Imaging performed after injection of dilute contrast media from middle hepatic artery (A4)
No contrast effect observed at S4 HCC. TACE not performed from the same artery due to possibility of extrahepatic blood supply
g) Follow-up CT angiography: Shows shrinkage of S4 HCC and no contrast effects inside HCC. Determined to be spontaneous necrosis (case of severe necrosis).

3. Summary

The increasing age of patients undergoing hemostasis surgery in emergency medicine or scheduled procedures often results in poor DSA images during IVR procedures due to inadequate breath-holding and other problems. However, being able to use RSM-DSA in addition to normal DSA has increased substantially the range of imaging used in procedures. Also, using cone beam CT during TACE for hepatocellular cancer is likely to help the prevention of so-called human error, including the misidentification of tumor feeding vessels.

Vascular

Experiences Using "unity smart edition," a New Version of Shimadzu's Angiography System

Masao Doushita, R.T.

Department of Radiology, Yawata Medical Center
Masao Doushita

1. Introduction (Hospital Description)

Yawata Medical Center **(Fig. 1)** is located in Komatsu City on Kaga Plain in the Minami Kaga area, Ishikawa Prefecture, where it commands a view of Mount Haku. The center is a secondary emergency core hospital with 227 beds for 18 medical departments and 4 specialty outpatient clinics in total. With acute care wards, recovery and rehabilitation wards, and community integrated care wards, the center provides a wide range of medical care and has established itself as a place of healing and relaxation. As a hospital that aims to prevent illness, in addition to medical treatment, Yawata Medical Center also provides health services, secondary prevention, rehabilitation as tertiary prevention, health improvement services in cooperation with neighboring health improvement facilities, and day care and home-visit nursing services.

The main focus of medical care at Yawata Medical Center is in cardiovascular internal medicine and orthopedic surgery, and the center takes in around 700 cases by emergency transport every year.

A characteristic feature of cardiovascular internal medicine at Yawata Medical Center is a cloud ECG communication system (prehospital ECG) for emergency patients used in coordination with neighboring emergency and rescue teams, including those in adjacent prefectures, to improve the door to balloon time in cases of acute myocardial infarction and achieve early diagnosis and treatment. Yawata Medical Center is the only facility in the Hokuriku region designated by the Japanese Association of Cardiac Rehabilitation as a training facility for cardiac rehabilitation instructors, and also pays close attention to potential risk factors for heart disease such as sleep disorders, diabetes mellitus, and periodontal disease. A variety of endeavors are being implemented with multidisciplinary cooperation, such as CPAP treatment for sleep apnea syndrome, and introducing diabetic dialysis prevention guidance management in the form of a "disease management MAP" for prevention of diabetic progression.

2. Background to Introduction of unity smart edition

When Yawata Medical Center first started performing cardiac catheterization, the first system acquired by the center was Shimadzu's DIGITEX α Plus in October 2001. DIGITEX α Plus had an established reputation for good image quality at the time, and was upgraded almost 10 years later in July 2011 to the BRANSIST safire HC9 (hereinafter, "BRANSIST safire"), equipped with a direct-conversion FPD. This new system was acquired with the expectation

Fig.1 **(a)** Exterior View and **(b)** Lobby View of the Center

of improved image quality, more software features, and the opportunity to advance efforts in X-ray dose reduction.

Procurement of this new system coincided with the Department of Radiology attempting to be certified as a facility with measures aimed at X-ray dose reduction, and allowed for serious work to be done in X-ray dose reduction. After acquiring the BRANSIST safire, re-examination of X-ray doses from angiography systems revealed they produced an X-ray dose that was greater than anticipated, and BRANSIST safire was used to achieve a major result by reducing the X-ray dose by approx. 20 % from default levels. Of course, this reduction took place in consultation with doctors of cardiovascular internal medicine to ensure image quality was not affected in a way that was clinically unfavorable. This dose reduction work was well-received, and in the following year on November 1, 2012, Yawata Medical Center received certification as a facility with measures aimed at X-ray dose reduction from the Japan Association of Radiological Technologists.

This year marks the seventeenth year since Yawata Medical Center started performing cardiac catheterizations, and over this period the angiography systems used by the center have evolved considerably, from I.I-equipped systems to FPD-equipped systems. Starting with CAG, the center has experience in performing a wide range of cardiac catheterizations, including PCI, EVT (catheter-based treatment for peripheral arterial disease) and ABL (catheter ablation). I still remember when we first introduced an FPD-equipped system, and being shocked at the ease of use and image clarity. Nevertheless, on using the system with more and more patients, we also recognized some inadequacies in the image quality. For example, image quality was inadequate when working from the right coronary artery (LAO 60°) or with patients who were large in stature, and upon encountering a total occlusion, the associated increase in catheter-based procedure times resulted in an excessive X-ray dose. These problems also overlapped with device evolution and demand for low-dose examinations during which physicians of cardiovascular internal medicine complained about X-ray doses and the low visibility of catheter tips. These problems were presumably a cause of much stress among physicians. The center was considering an upgrade because 6 years had passed after introducing the BRANSIST safire, but upgrades to other modalities took precedence at the time. However, around this same time, Shimadzu proposed a version upgrade (reBORN) to our existing system that we decided to consider.

Some of the benefits of reBORN:

(1) A version upgrade that improves the existing system to the latest system

(2) Uses the latest software that assists with clinician procedures.

(3) Simultaneously reduces X-ray dose and improves image quality.

(4) Above all else, is cheaper than obtaining a new system (consumption tax was also soon to be increased).

After thorough consideration, a version upgrade was approved.

3. Circumstances and Experiences of System Use

Around half the approx. 400 catheterization procedures performed in 2017 included therapeutic intervention. Although the number of cardiac catheterizations being performed has been falling for several years, this is speculated to be due to improvement of the coronary artery restenosis rate by improved physician skills, device evolution, and improved cardiac rehabilitation. This fall was also presumed to be due to a reduction in diagnostic catheterizations caused by advancements in coronary CT angiography and the improved ability of surrounding facilities to take on cases. The ongoing fall in cardiac catheterizations is therefore perceived in a favorable light and as a positive trend for local residents.

I will now move onto describing our use of the unity smart edition **(Fig. 2)**, which is the version upgrade (reBORN) of our BRANSIST safire. The change from a direct-conversion FPD to an

Fig.2 unity smart edition

indirect-conversion FPD removed the need for strict temperature and humidity management of the FPD. Although the external size of the FPD remains almost unchanged, the effective field of view has increased from 9 × 9 inches to 12 × 12 inches, and the diagnostic performance of the system has improved in lower extremities and the abdominal region. Although we are currently using an 8-inch and not the conventional 7.5-inch for coronary arteries, we are considering a move to 6-inch operation in the future.

There have been 101 cardiac catheterizations performed in the period between the version upgrade (reBORN) in March and the end of May this year. Image quality has been very well-received by physicians of cardiovascular internal medicine, both in fluoroscopy and radiography. This is thanks to the introduction of new image processing technology in the form of SCORE PRO Advance, which has features that include motion tracking noise reduction to detect subject movement for improved tracking and noise elimination abilities, and the use of object extraction enhancement to extract and enhance important structures for substantial improvements in thin vessel extraction and device visibility.

Despite reducing the fluoroscopy pulse rate from 15 fps to 7.5 fps, fluoroscopy images are improved compared to the previous system at the higher pulse rate of 15 fps. Comparison of radiography images against the previous system also shows a clear improvement in contrast and resolution **(Fig. 3)**. The system is now also better for patients with a mean patient X-ray dose from CAG that is approx. 40 % lower than the previous system **(Fig. 4)**.

Yawata Medical Center also has a focus on EVT, and performs approx. 50 therapeutic procedures each year. DSA imaging is frequently used during EVT, and comes with the Flex-APS function that performs adjustments down to the individual pixel-level. Flex-APS even allows adjustment for twist motion, and has increased our ability to remove bones and improve image quality. Arterial interventions in the lower extremities are performed quite frequently in recent years for improvement of QOL, and Flex-APS is particularly effective in extracting fine vessels in the extremities.

With regard to manipulation of the table and C-arm, the cyber grip has been replaced by the cyber console. Controls for C-arm rotation and travel are now separate from controls for distance from the FPD. There have been some complaints that this increases the number of manipulations that require two hands to complete, so this change is something that requires a little more time to become familiar. A SMART Touch digital console has also been placed beside the cyber console **(Fig. 5)**. SMART Touch combines a touch panel with lever manipulation, and integrates successfully the advantages of a touch panel that allows customizable screen layout with the analog advantages of the previous IVR-NEO digital console. The same SMART Touch digital console is also installed in the control room and allows for switching between fluoroscopy and radiography modes by the same method used in the examination room. The touch panel can also

Fig.3 Comparison of Radiography Images
(a) Previous system **(b)** unity smart edition

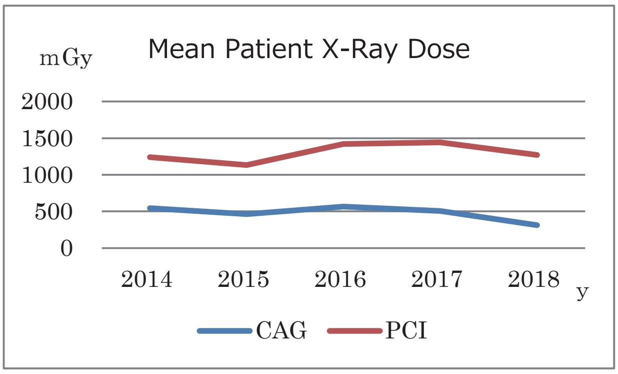


Fig.4

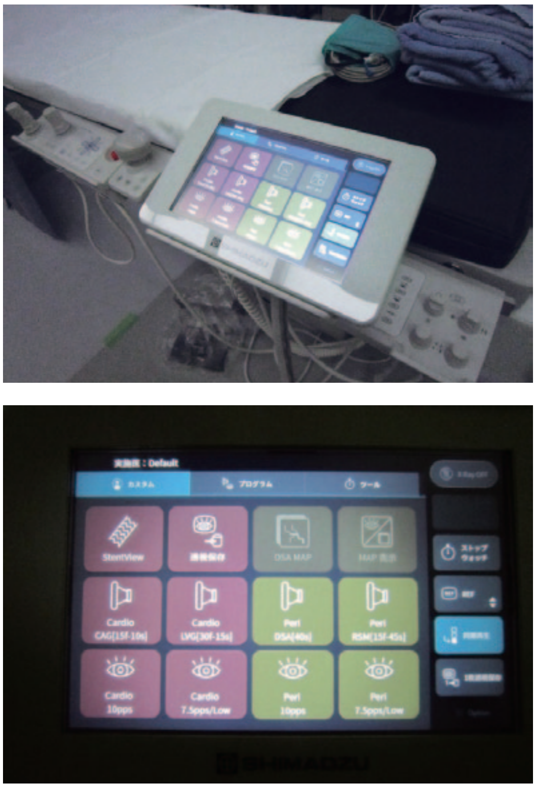


Fig.5 SMART Touch Digital Console

be customized with functions commonly used for certain procedures or for particular physicians, which allows physicians stress-free control.

We have also obtained the latest version of SCORE StentView PCI support software. SCORE StentView displays stents in a fixed position by compensating for heart movements, which helps positional confirmation when overlapping stents and during post-dilatation of stent with balloon. The previous software was unable to recognize the stent adequately in some cases, and image quality was also inadequate. The latest version of SCORE StentView promises improved visibility as it shows the stabilized stent in a whole screen view. Since this software has only been used a limited number of times, we have yet to verify it fully, but intend to make effective use of SCORE StentView in the future.

4. Summary

Shimadzu's proposition for a version upgrade of our BRANSIST safire to the unity smart edition occurred with especially good timing. With the variety of applications that were included in this version upgrade, I feel like our BRANSIST safire has been transformed into a system that physicians can now use stress-free for diagnoses and procedures. Lately, despite ever-greater demands for improved fluoroscopy and radiography image quality, it is taken for granted that X-ray doses will also be reduced. Although demands from users are anticipated to become much more specific in the future, I hope Shimadzu will consider the voice of the end user as a useful guide in future product development.

Vascular

Development of Trinias Series unity smart edition Angiography Systems

Medical Systems Division, Shimadzu Corporation
Isao Nakanishi

1. Introduction

The Trinias series of angiography systems has been introducing ever more functions and proprietary image guidance applications to support minimally invasive treatment (reduced exposure, reduced contrast media usage, and reduced examination times). Recent years have seen a rapid increase in the sophistication of interventional technologies, with therapeutic equipment becoming smaller and more delicate, just as a wider variety of functions are required of angiography systems.

Therefore, based on the "unity" concept*, the Trinias series unity smart edition model was designed to be more user-friendly and compact, and features unique imaging guidance software for supporting the latest treatment procedures. This article describes that software and functionality.

*unity: unlimited intelligent technology

2. Concepts of “unity”

In recent years, users have been demanding systems capable of sophisticated and diversified interventional procedures for all areas of the body, such as the head, abdomen, heart, and four extremities. To offer a new minimally invasive experience for all sorts of interventional procedures anticipated from future advances in interventional technologies, the Trinias series unity model is a more advanced system that was designed based on the following three unity concept elements.

- Personalize your experience for ultimate flexibility
- Intelligent design for intelligent care
- Limitless potential for efficient workflow

3. Trinias Series unity smart edition

The unity smart edition was designed to enable a wide variety of procedures using a single system, so that sophisticated interventional procedures can be performed with few personnel and limited space. Equipped with either a 12 × 12-inch or 16 × 12-inch FPD, users can choose the best field of view for their target treatment area **(Fig. 1)**.

Fig.1 Trinias Series unity smart edition
Available with 16 × 12-inch FPD (left) or 12 × 12-inch FPD (center and right)

3.1 Personalize your experience for ultimate flexibility

The unity smart edition features a completely updated system configuration, so that sophisticated interventional procedures can be performed in a confined space with minimal personnel. Requiring about 30 % less cabinet installation floor space as the previous model, the system offers more flexible room layout in installation planning. It also eliminates the cabinet from the control room, which ensures a larger workspace in the control room.

To support diverse procedures throughout the entire body, the FPD cover size was minimized, freedom of positioning was increased. It enables to approach close to the patient even at a steep angle in heart cases **(Fig. 2)**. The 16 × 12-inch FPD can be rotated to either portrait or landscape orientations, so that the field-of-view size for fluoroscopy and radiography can be selected based on the target area **(Fig. 3)**.

The new user interface ensures smooth examinations. By displaying X-ray parameters, dose information, and positioning information on the live monitor **(Fig. 4)** to minimize having to look away, physicians

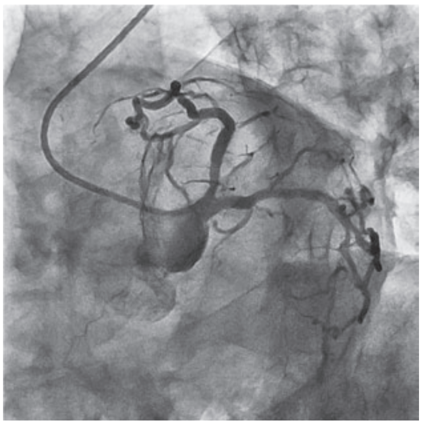
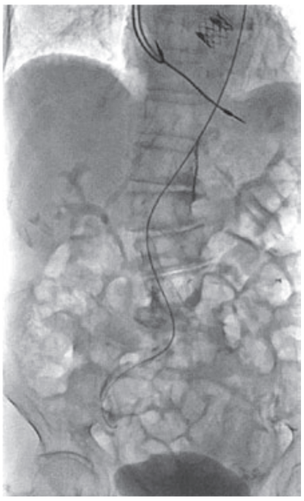


Fig.2 Supports Imaging the Heart Area



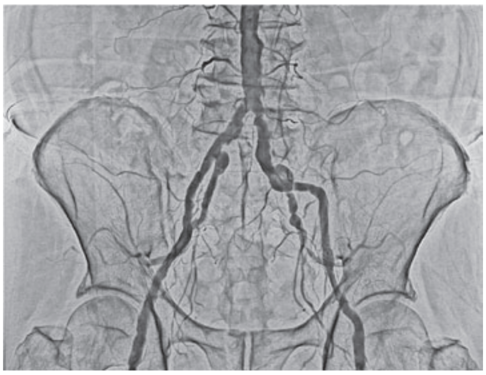


Fig.3 16 × 12-Inch FPD in Portrait and Landscape Orientations

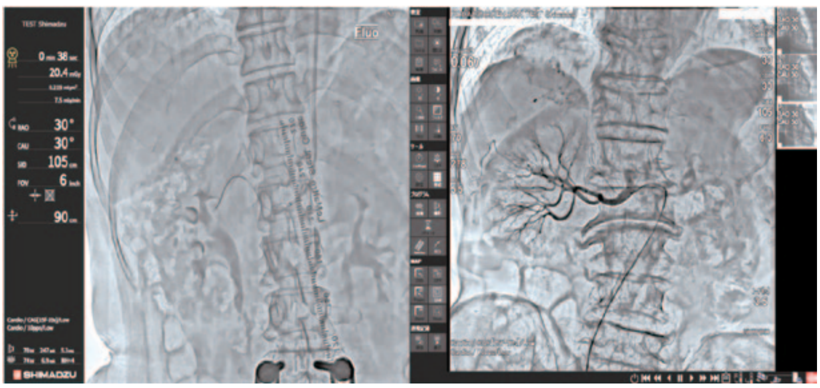


Fig.4 New GUI Minimizes Moving the Line-of-Sight

can focus more on the procedure. To provide more intuitive operations, all system come standard with a SMART Touch digital system controller, with functions that can be freely customized based on the operating circumstances. A wireless foot switch is also available that can be assigned to fluoroscopy, radiography, or even table up/down movement operations **(Fig. 5)**.

3.2 Intelligent design for intelligent care

The unity smart edition was designed to prioritize highly reliable and worry-free performance for both the user and patient.

To improve system reliability, the system was designed for simplicity, such as a new communication method that reduces the cables between the control room and machinery room to one seventh the previous level. Furthermore, high product quality is achieved by performing all manufacturing and quality control process steps at the Main Factory in Japan.

3.3 Limitless potential for efficient workflow

A major design concept of even previous Trinias systems has been “minimally invasive experience“ to minimize overall invasiveness, such as by reducing exposure, reducing contrast media usage, and reducing examination times and by developing applications that provide a real-time operability. The unity smart edition features a more advanced version of Shimadzu's proprietary SCORE imaging technology, which achieves a new minimally invasive experience.

3.3.1 SCORE StentView and SCORE StentShot PCI Support Applications

The ability to accurately confirm device information, such as for accurate stent positioning and degree of stent expansion after placement, is very important during PCI.

SCORE StentView is an application that provides support for accurate real-time device placement. Based on images with a heartbeat, it displays moving images with minimal noise and with the stent enhanced **(Fig. 6)**. Because images are displayed in real time on the live monitor, in the same manner as during regular fluoroscopy or radiography, positioning can be adjusted while viewing the live monitor.

SCORE StentShot is especially useful for confirming the shape of stents in detail. While offering the same real time performance as SCORE StentView, SCORE StentShot can provide more detailed stent images by successively integrating all frames during X-ray exposure **(Fig. 7)**. Because successively integrated stent images are displayed in real time on the live monitor, X-ray exposure can be

Fig.5 SMART Touch Control Panel (upper) and Wireless Foot Switch (lower)

stopped as soon as the stent shape is adequately confirmed, so that unnecessary exposure can be avoided.

3.3.2 SCORE Chase EVT Support Application

Frequency subtraction application “SCORE RSM” doesn’t require mask acquisition, and is free from motion artifact. So it has been widely used for motion-tracking radiography of the lower extremities and other long areas. SCORE Chase strengthens the link between a digital system and the patient table and automatically stitches motion-tracking images, obtained with SCORE RSM or another application, so that the entire imaged area can be observed at the same time **(Fig. 8).**

The stitched image of the entire area is displayed immediately after acquiring motion-tracking images, so that the images can be used during examinations without any wait time. The application not only supports table movements in the longitudinal direction, but also in the transverse direction **(Fig. 9)**. It can also create an image of all areas acquired by motion-tracking in the free-panning mode. Consequently, it offers a simple and smooth workflow.

3.3.3 Flex-APS Real-Time Nonlinear Pixel-Shifting Process

Pixel-shifting processes that translate, rotate, enlarge, or reduce the mask image with respect to the live image can be used to correct misregistration artifacts in DSA images, but sometimes adequate correction cannot be achieved, because actual clinical applications often involve three-dimensional movement with twisting. Flex-APS (flexible active pixel shift) calculates appropriate correction factors for the entire image by calculating the patient movement between mask and live images for each individual pixel of the exposure area and then applying different correction factors for each

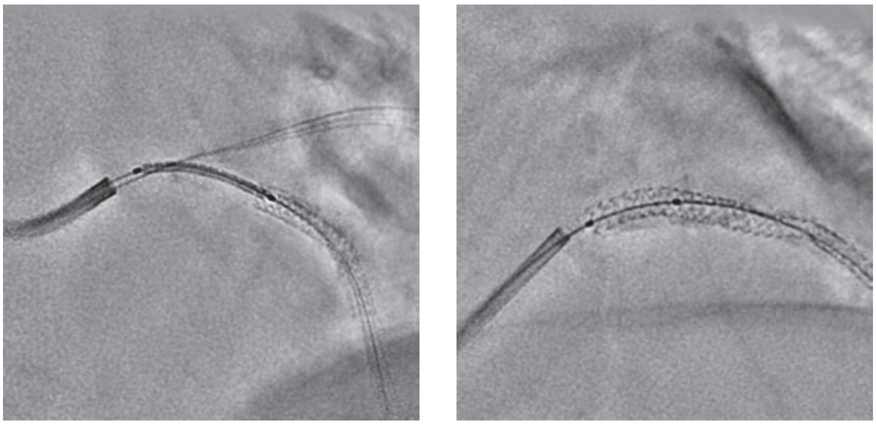


Fig.6 SCORE StentView

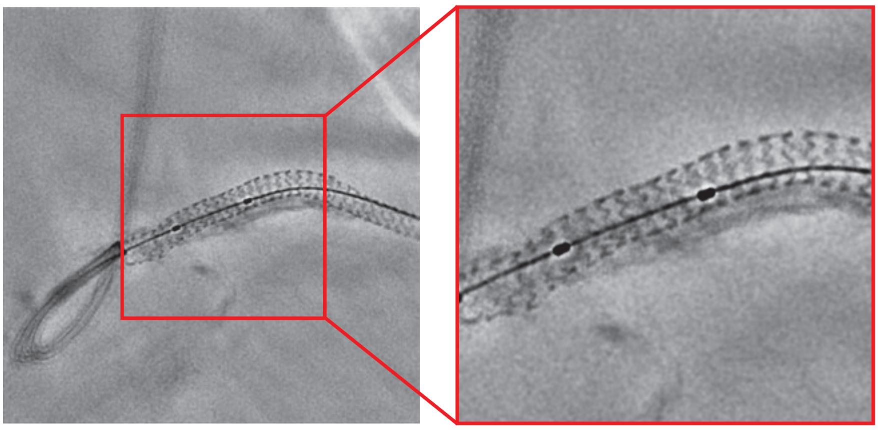


Fig.7 SCORE StentShot

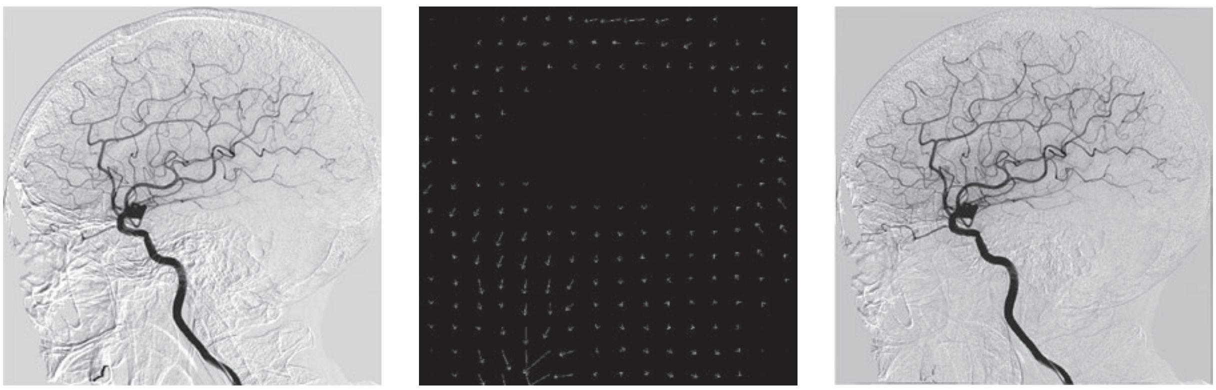
Fig.8 SCORE Chase

pixel **(Fig. 10)**. Because the series of correction steps are performed in real time, images of blood vessels can be observed with misregistration artifact correction even during acquisitions, which can significantly reduce the time and trouble required for post-processing. It can also help avoid unnecessarily high X-ray dose and contrast media levels by decreasing the number of repeated acquisitions.

4. Summary

Trinias series unity smart edition angiography systems are based on technology included in previous models for supporting minimally invasive procedures, but the unity smart edition also has been developed to support increasingly sophisticated and diverse interventions. Together with everyone involved in interventional procedures, we will continue to develop advancements intended to achieve less invasive and higher quality healthcare. Finally, we would like to thank the doctors and others that offered their generous help during product development.

Fig.9 Free-Panning Mode



a) Without Correction **b)** Dynamic Motion Vector **c)** After Correction

Fig.10 Flex-APS

Minimally Invasive Procedure in Practice

—Efforts by Iwate Prefectural Central Hospital—

Engineering Center, Shimadzu Medical Systems Corporation
Miyuki Shoji

Due to the increasing complexity and sophistication of treatments for arrhythmia in recent years, there is a demand for angiography systems capable of reducing exposure, reducing contrast media usage, and reducing examination times. Shimadzu's latest angiography systems, the Trinias series, feature various unique functionality for achieving a minimally invasive experience.

This article describes the minimally invasive procedure practices at the Iwate Prefectural Central Hospital where a Trinias series system was introduced.

1 Application of an Ultra-Low Dose Fluoroscopy Mode

One non-pharmacological treatment for arrhythmia is catheter ablation, but the procedure is often time-consuming and results in higher X-ray dose levels to patients and physicians. Therefore, the procedure requires consideration for minimizing fluoroscopy dose levels.

There are two main methods for reducing the X-ray dose during fluoroscopy, either (1) reduce the pulse rate or (2) reduce the dose per pulse. Trinias systems offer a low-dose mode that uses both methods (1) and (2) to reduce the X-ray dose rate by about 44 %, compared to the normal fluoroscopy mode. Additionally, an extra-low dose "ExLow" mode using X-ray control for pediatric protocols can reduce X-ray dose rates by about 63 %.

The Iwate Prefectural Central Hospital uses the ExLow mode and a low 5 pps pulse rate mode for catheter ablation procedures to keep X-ray dose levels as low as possible. That reduces the X-ray dose rate by about 81 % **(Fig. 1)**.

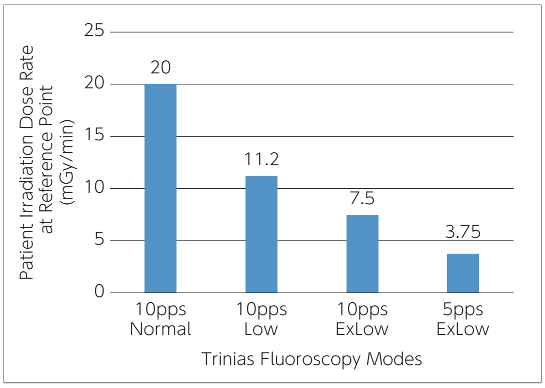


Fig.1 Comparison of Radiation Dose rate by Fluoroscopy Mode

Patient irradiation dose rate at reference point with 8-inch FOV and 20 cm acrylic phantom.

* Measurement data that appears in Shimadzu's clinical manual. The 5 pps value has been calculated.

2 Application of Fluoroscopy Record Function

In the case of radiofrequency catheter ablation, the ablated locations on the heart muscle must be recorded many times. We use the fluoroscopy record function for that recording process. Conventional DA radiography and OneShot

A Word from Hideaki Endo, M.D., Ph.D., Chief of Cardiovascular Internal Medicine

At our hospital, the SCORE Navi+Plus application, which produces 3D roadmaps using CT images, is used for cryoablation procedures. Using some of the features given in this article, CT images can now be accurately overlaid on the fluoroscopy images. It provides anatomical information as good as a 3D mapping system, allows us to quickly select appropriate pulmonary vein procedures and helps reliably achieve pulmonary vein isolation. Based on these features, it can be expected to shorten fluoroscopy time greatly, and it will be a useful tool for balloon ablation, which is expected to become more widely used in the future.

radiography could also be used for recording ablations, but that would increase the X-ray dose level. By using the fluoroscopy record function after watching the catheter tip by fluoroscopy, additional X-ray doses can be eliminated, which results in lower X-ray dose levels.

Fluoroscopy images can be recorded from either the control room or from a bedside console without time loss. Also, it is unnecessary to switch the mode before the start of the next fluoroscopy, so that the procedure can be performed smoothly.

3 Application of SCORE Navi+Plus

At the Iwate Prefectural Central Hospital, the SCORE Navi+Plus application, which produces 3D roadmaps using CT images, is used for cryoablation procedures.

The following measurements are taken at the time CT images are acquired for SCORE Navi+Plus. (1) They use a flat headrest as much as possible for CT scan, similar to headrests used for angiography. (2) Arms are not raised during scans. (3) Patients are scanned with multiple markers applied to their body surface, so that the markers can be used as reference points when overlaying CT and fluoroscopy images. (4) As far as possible perform the CT scan on the day before the examination.

Since the two images from different modalities need to be overlaid, a different method than for regular CT scans is used for (1) and (2), so that body locations can be aligned more easily. Puncture markers **(Fig. 2)** that do not cause artifacts in CT images are used for (3) and are also selected for cost considerations. In anticipation that markers might fall off, marker locations are also marked with a marker pen.

After scans, the CT system is used to generate data excluding the left ventricle, which is loaded into the SCORE 3D workstation, so that various VR images (left atrium, bronchi, and vertebral bodies) can be immediately generated at the workstation **(Fig. 3)**.

Registration (alignment between CT and fluoroscopy images) is required if SCORE Navi+Plus is used, so the Iwate Prefectural Central Hospital uses markers at PA/RAO50° locations and the bronchial bifurcation as reference points for registration. Affixing the markers helps with understanding the vertical positional relationship between vertebral bodies, respective magnification rates, and so on **(Fig. 4)**.

During procedures, a single click is required to switch between front and back views. In addition, VR images can be adjusted while in the roadmap mode and roadmap images automatically track C-arm rotation movements to prevent inhibiting the progress of procedures and help shorten examination times **(Fig. 5)**.

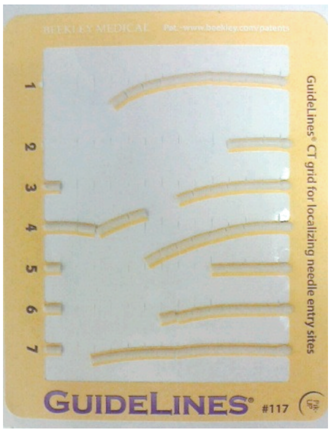


Fig.2 Marker (made by BEEKLEY MEDICAL)

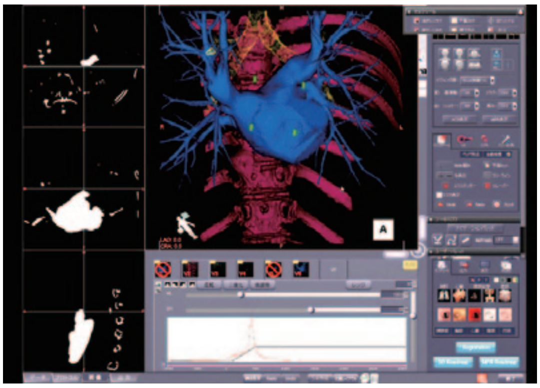


Fig.3 Volume Addition

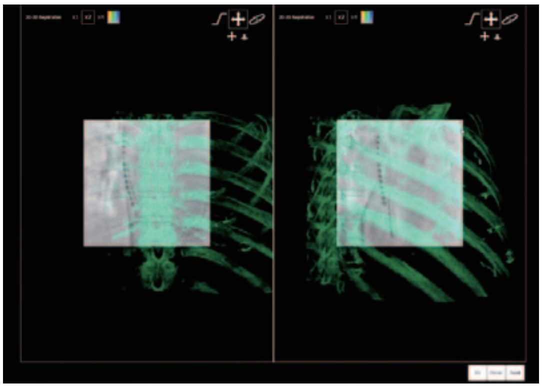


Fig.4 Image Registration

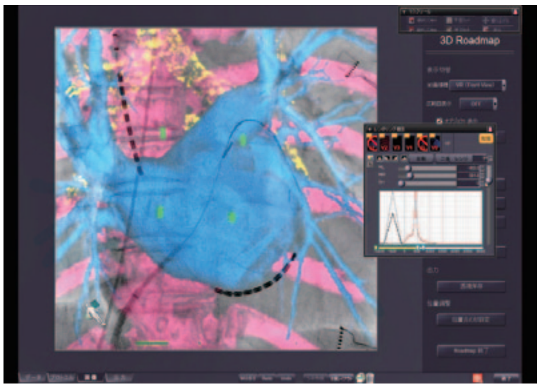


Fig.5 3D RoadMAP

RAD

Easy-to-Operate MobileDaRt Evolution MX8

Shoichiro Nanjo, R.T.

Department of Radiology, TMG Asaka Medical Center
Shoichiro Nanjo

1. Introduction

The TMG Asaka Medical Center **(Fig. 1)** is located in Asaka, a city in the southern part of Saitama Prefecture. The closest train stations are Kita-Asaka on the JR Musashino Line and Asakadai on the Tobu Tojo Line. Due to its proximity to downtown Tokyo, Asaka has prospered in recent years as a bedroom community of Tokyo.

Our hospital was originally established in April 1977 as Asakadai Central General Hospital, with 122 beds. After that, it was expanded to 236 beds in 1981 by building the new wing, and to 268 beds the following year. Then, in 1988, the hospital was renamed the Asakadai Central General Hospital. In addition, a group medical screening center was established in an attached facility in 1996 and the hospital was reopened after further expanding all buildings to a total of capacity of 326 beds (3832.96 m^2 floor area).

Forty years after the hospital was first established in this location, based on a hospital philosophy of being a "Hospital that Loves and Is Loved Based on Sophisticated Healthcare" and "Healthcare That Treats Patients Like Family," and after two years of construction, the hospital was finally moved to the current site in January of this year (2018) and renamed the TMG Asaka Medical Center (4887.05 m^2 floor area). The new facility has 446 beds and 805 employees (including 78 doctors, 385 nurses, and 195 medical support personnel), of which 33 are radiological technologists.

Fig.1 TMG Asaka Medical Center

Even after relocating, we remain committed to implementing the hospital philosophy by daily practicing the following five things.

(1) Provide healthcare in close cooperation with the local community and other medical institutions in the region.

(2) Provide a 24-hour emergency care system through partnerships with other organizations.

(3) Ensure the hospital can provide healthcare concurrently to multiple people.

(4) Provide training to develop conscientiousness and improve technical skills as medical professionals.

(5) Provide sophisticated healthcare by introducing state-of-the-art medical equipment.

2. Background for Introducing Equipment

Our hospital previously used computed radiography (CR) for our portable X-ray system, but as it was deteriorating with age, we introduced a flat panel detector (Canon) in 2014, which we used in combination with a Shimadzu MobileArt Evolution mobile X-ray system. At the previous Asakadai Central General Hospital, not much progress had been made toward converting systems to Information Technology. The only networking system in our hospital was the Hospital Information System (HIS). Without any RIS or PACS systems in the Department of Radiology, the department operated based on analogue film. Consequently, portable radiography at the time involved the following steps that combined digital and labor-intensive methods.

(1) Confirm the X-ray acquisition order with the PC terminal in the radiology department.

Fig.2 Large 19-Inch Monitor

Fig.3 MobileDaRt Evolution MX8

(2) Manually transfer the order information to the FPD management terminal.
(3) Transport the FPD and FPD management terminal to the patient's ward or operating room and visually verify the patient ID wristband before starting radiography.
(4) Return to the department to process and check images before outputting film.
(5) If necessary, carry the film to the operating room to have it checked by the doctor.

Because we were using an FPD, we could view images on the FPD management terminal immediately after radiography, but the terminal screen size was only about ten inches, which was not big enough to display entire images. Some doctors expressed that the small screen size made it difficult to check images. To be able to confirm catheter tip and implant information, the doctors began demanding larger monitors in the operating theater or elsewhere. As we continued to use our portable radiography system, we began wondering if there was a way to operate the system without having to physically carry the FPD unit and laptop computer around. Therefore, to solve that situation, we reviewed the FPD-equipped portable X-ray systems available from respective manufacturers. That resulted in introducing the user-friendly MobileDaRt Evolution MX8 **(Fig. 3)**, which features excellent maneuverability, quiet operation, and a large 19-inch monitor **(Fig. 2)** that improves examination efficiency by displaying images that doctors can check on-site where the radiography was performed.

3. Hospital Environment

As mentioned above, the TMG Asaka Medical Center was moved to the current site and opened as a new hospital on January 1 of this year.

We use Fujitsu HOPE/LifeMark-HX as HIS system, Fujifilm SYNAPSE as PACS system, Infocom iRad-RS as RIS system, and Infocom image inspection system.

With the HIS system accessible wirelessly throughout the hospital, order information can be obtained and images transmitted at any time.

4. Workflow

The hospital uses the MobileDaRt Evolution MX8 system in operating rooms and the ICU, where workflow has been streamlined accordingly, as follows.

(1) The doctor requests portable radiography via the HIS system.
(2) After confirming the order in the RIS system, the MobileDaRt Evolution MX8 system is driven to the operating room or ICU, started up, and order information is obtained from the in-hospital network.
(3) The patient ID is read from the patient's wristband and corresponding patient information is obtained from the modality worklist management (MWM) system.
(4) Radiography is performed.
(5) Images are checked and processed on the monitor equipped with the MobileDaRt Evolution MX8 and transmitted to the image inspection system.
(6) Personnel examine the images on the image inspection system terminal in the Department of Radiology.
(7) Images are transferred from the image inspection system terminal to the PACS system.

5. Experience Using the MobileDaRt Evolution MX8 System

5.1 Telescopic Column

The best feature of the system, after all, is the telescoping capability of the column on the portable X-ray system. That feature allows lowering the top of the column to a height of 127 cm and the top of the X-ray tube to 124 cm, which opens up the forward visibility during driving. That means that even very short technologists can safely drive the units (the technologist in the photo is 150 cm tall). It is also less intrusive for other patients in the area. Given the trend of increasing bed heights in the ICU, sometimes we cannot keep 100 cm SID or enough exposure field size before, but now that the focal point can be raised up to 202.5 cm, we no longer have such problems (Fig. 4).

5.2 Large Monitor

The screen on the laptop computer included with the FPD unit is so small that we did not use it to confirm clinical information. In contrast, the MobileDaRt Evolution MX8 includes a large 19-inch monitor that enables the catheter tip and implant locations to be confirmed on-site without checking images on the PACS system. That has been popular with doctors, because it saves time and improves productivity (Fig. 5).

5.3 Positioning

Due to the smooth overall movements of the support mechanisms and drive system, with minimal vibration, the system can be moved very quietly. All the switches are extremely user-friendly to operate. For example, fine positioning adjustments are possible by parking the system relatively close to the bed, putting the FPD under the patient and then operating the switches on top of the collimator to move the system forward or backward. The exposure field lamp buttons and the exposure field aperture knobs on the front and back of the collimator also make it easy to position the exposure field (Fig. 6).

5.4 Storage Space

One surprisingly valuable feature is the many storage areas provided. The storage box can hold both full size and compact FPDs and also a grid for eliminating scattered radiation. The FPD storage slots have a locking function to prevent theft or mischief.

Fig.4 Visibility During Driving

Fig.5 Inside Operating Room After Surgery

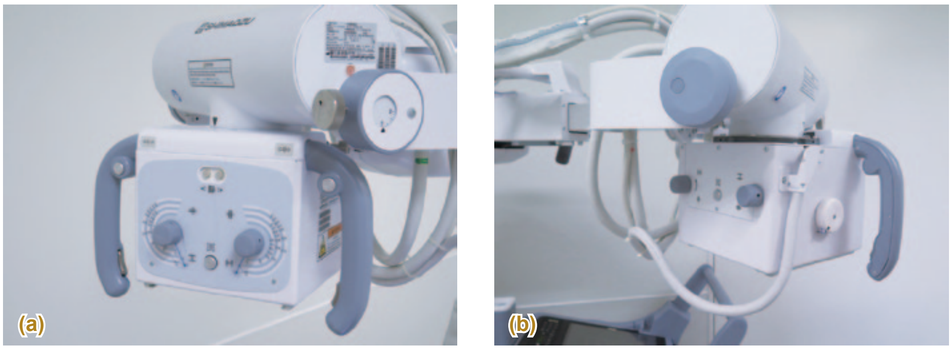


Fig.6 Front (a) and Back (b) of Collimator
Exposure field lamp buttons and exposure field aperture knobs are provided on both sides.

5.5 Options

Since the system has pin code login function, there is no need to carry a key and no worry about losing the key. It also eliminates the trouble of having to get the key to the specified storage location if the operator is called away to another location.

In addition, a wireless barcode reader can be used to verify patient ID and match patients with examination orders, even for patients with difficulty communicating, which simplifies the radiography preparation process and prevents examining the wrong patient or region.

Furthermore, a wireless exposure switch **(Fig. 7)** enables starting exposures from a distance to minimize exposure levels to technologists.

After acquiring images, the images can be checked, marks inserted, brightness or contrast adjusted, or other image processing instructions can be sent to the image inspection system terminal on-the-spot, in the same manner as for general radiography. That has significantly reduced the time needed for portable radiography from acquiring images to sending them to the image inspection system terminal. However, it also requires being careful to make sure both the FPD unit and the portable X-ray system are adequately charged.

Fig.7 Wireless Exposure Switch

So far, as of three months since we started using the system, we have experienced no errors or any other problems.

6. Summary

First we introduced a Canon mobile FPD unit in 2014 and then started using it in combination with an existing Shimadzu MobileArt Evolution system. Converting from CR technology meant we no longer had to carry the CR unit so many times and allowed us to check images on-the-spot, which has almost completely eliminated situations of having to go back to reacquire images after checking them back in the office. Consequently, our workflow efficiency has improved dramatically.

The doctors also like the system, because they can check the clinical images on the large monitor screen without leaving the patient.

The MobileDaRt Evolution MX8 we introduced this time helped solve many problems we were experiencing at our hospital. The attention to detail has resulted in a system that has performed as expected.

RAD

Experiences Using the RADspeed Pro EDGE Package

Hirohito Tanaka, R.T.

Department of Radiology, Chibune General Hospital
Hirohito Tanaka

1. Hospital Description

Our hospital was originally established in Tsukuda in 1958, near Chibune Station on the current Hanshin Main Line, as Chibune Clinic. As an acute care general hospital for the Nishiyodogawa Ward of Osaka City, the hospital serves an important role in providing healthcare for the region and also for providing perinatal, maternal, and child healthcare.
On July 1, 2017, our newly updated hospital was opened at a new location in front of the Fuku Station on the Hanshin Namba Line **(Fig. 1 and 2)**.
Built based on the concept of "Safety and Security for the Future," the earthquake-proof building designed to withstand natural disasters has nine floors with approximately 32,700 m^2 of floor area. Though the number of beds remains the same (292 beds), it is 2.5 times more spacious than the previous facility, so that patients can be provided with a more restful space. As before, the new Chibune General Hospital will continue to serve as an acute care general hospital for treating key diseases, such as diabetes, myocardial infarctions, strokes, and cancer, for providing adult healthcare involving the cardiovascular system, gastrointestinal system, kidney dialysis, cerebrovascular system, or gynecology, and for improving perinatal care. In addition, the hospital is actively involved in emergency care for foreign patients, thereby providing sophisticated healthcare that is safe and worry-free for a wide variety of Japanese and foreign patients.
The recent update involved replacing almost all of our diagnostic imaging systems. As part of that process, we introduced three new Shimadzu X-ray systems, including the RADspeed Pro EDGE package. The follow is a report of our experience with starting up the systems, starting clinical operations, and using tomosynthesis.

Fig.1 Exterior **(a)** of and View **(b)** from the Hospital

Fig.2 Hospital Front Desk

2. Background of Adoption

In terms of criteria for selecting a general radiography system for the relocated hospital, we needed to start the selection process with a blank sheet of paper, regardless of the manufacturer. As a result, the department personnel at the time prepared the following wish list.

- Ability to perform axial projection radiography of hip joints on both sides without having to reposition the patient

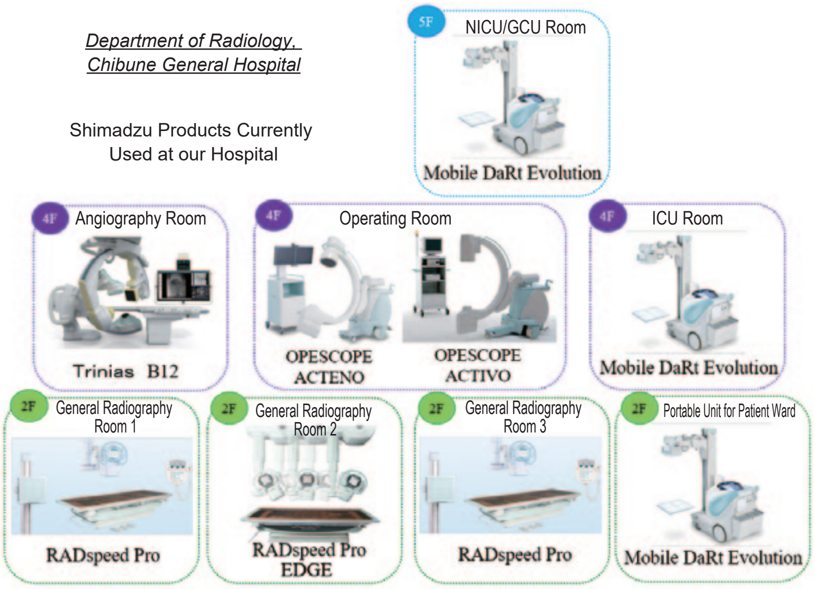


Fig.3 Shimadzu Products Currently Used at the Hospital

- Ability to fix the X-ray tube at any angle to accommodate a variety of radiography situations
- Ability to perform long view radiography easily and stitch images automatically
- Include a light-weight FPD with simple and user-friendly image processing operability.
- Include a wide variety of image processing functions, including a virtual grid function.

First, at the construction design stage, we decided to include three general radiography rooms, all capable of general radiography in standing and supine positions. The radiography room interiors were designed with enough space for flow line of the patient and technologist, for acquiring images either in a wheelchair or on the bed, and so on.

Since the general radiography systems would be used by all department personnel, the selection process was discussed many times. Based on experience using X-ray generators, an overwhelming majority recommended Shimadzu general radiography systems, due to easy operability and attention to detail. Other key reasons given included useful functionality, such as interlocking functions around the components, long view radiography, and auto-positioning, and the sincere and prompt services they provide. In terms of image processing, reasons included our expertise using Fujifilm's CR system, which was the first system to successfully offer digital X-ray imaging, extensive image processing technology, such as grid line elimination, multi-frequency processing, and noise suppression, the light weight design, with a 2.6 kg (at the time) 14 × 17-inch size FPD, while also providing a 310 kg load capacity. Consequently, we decided to introduce Shimadzu RADspeed Pro EDGE package which is

Fig.4 Layout of General Radiography Room 2

a general radiography systems in combination with Fujifilm FPD Digital Radiography system **(Fig. 3 and 4)**.

3. Cooperation between the RIS Terminal and the Image Processing System

For radiography orders input from electronic medical records in the HIS terminal (Fujitsu), the patient information and radiography request information is obtained from the RIS terminal (Fujitsu) via the modality worklist management (MWM) service and smoothly transferred to the X-ray high voltage generator (UD150B-40) via the Digital Radiography system (Fujifilm). Images with adjusted brightness and contrast are checked on the image inspection system terminal and then sent to the PACS system **(Fig. 5)**.

It automatically performs the "select the Anatomical Program," "select the X-ray exposure conditions," and "adjust the irradiation field size" steps, which were previously performed by technologists. That allows

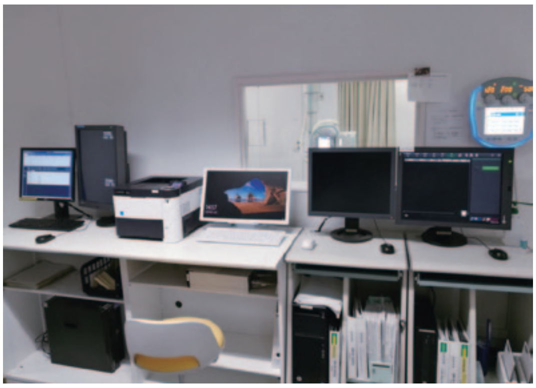


Fig.5 Control Room
(Right to left: UD150B-40, the image processing unit, the tomosynthesis image processing unit, the electronic medical record terminal, and the image inspection system terminal)

the technologist to focus on assisting and positioning the patient, which, needless to say, significantly reduced the number of mistakes made selecting the Anatomical Program and X-ray exposure conditions.
However, in order to cooperate the entire process, from RIS terminal to image processing unit, an electronic medical records and RIS master database needed to be prepared before the system was introduced. That required specifying radiography parameters for the examination protocol for each target region, and required interlocking the RIS, image processing unit, and X-ray high voltage generator and verifying the link. Therefore, I want to express my gratitude to the technologists that entered and checked all those settings and say how happy everyone in the department is with how much easier the environment is to work in now.

4. Our Experience Using the Function for Interlocking the Ceiling-Mounted X-Ray Tube Support with the Digital Radiography system

After patient information is registered, then radiography study begins. The tube is automatically controlled by a wired remote controller **(Fig. 6)**. A technologist can operate it under watching the whole radiography room and confirming the patient position. If the switch is released during remote control operations, the tube movements stop immediately to ensure safety.
Also, a technologist can confirm the patient information at the LCD panel attached to the ceiling-mounted X-ray tube support. When the Bucky stand is raised or lowered during radiography based on patient height, the X-ray tube support also instantly moves accordingly.
The X-ray tube support also moves automatically when the Bucky table is raised to keep the appointed sauce -to-image distance (SID). When the Bucky table is lowered, the movement can be interlocked with the specified SID with a single press on the X-ray tube support switch. Maintaining a constant SID value previously involved measuring the distance with a tape measure, but now the SID can be easily confirmed on the LCD panel.
Hip joint images can be acquired from both sides without any difficulty due to a swivel rotation function of the X-ray tube support, which can be stopped at any angle and fixed securely.
There are also inconspicuous buttons hidden on the back side, near the bottom of the column. They include swivel rotation, all-free, and collimator lamp illumination buttons **(Fig. 7)**, which are very convenient for retracting the X-ray tube above a

Fig.6 Auto-Positioning

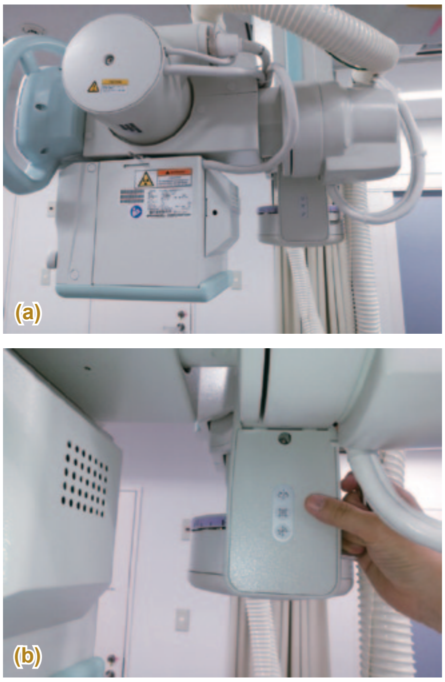


Fig.7 **(a)** X-Ray Tube Support
(b) Bottom of Support Column

gurney during an emergency, for example. We find this and other extensive functionality, which is not available from other brands, very useful.

5. Experience Using Long View Radiography

Previously, long view radiography involved mounting two or three 14 × 14-inch size imaging plates in a long CR cassette. After acquiring the images, the long cassette was replaced with a 14 × 14-inch cassette and load them to the reading equipment. Thus, it took about 10 minutes for each long view radiography. Furthermore, it was necessary to perform the post processing for three images and print them to the film, and to join the three sheets with adhesive tape. Not only did that require extremely tedious work by the radiological technologist involved, but if both lower extremities were acquired in two projections, then it would keep the radiography room occupied for long periods which was one of the things we wanted to improve the most.

After the new system was introduced, the fender wall for long view radiography looked very substantial, but was actually surprisingly light and moved smoothly, so it did not cause any problems in terms of taking up space in the radiography room **(Fig. 8)**. When placed in front of the Bucky stand, the fender wall can be fixed with two pin halls to prevent it moving when the patient steps up or down from it. If either pin is not engaged, a warning is displayed on the LCD panel attached to the X-ray tube support and radiography is disabled. Using a system designed with such consideration for patient and technologist safety is very reassuring. Large grip bars are provided on both sides to help patients step up/down from the fender wall easily. They are also very helpful for keeping proper posture.

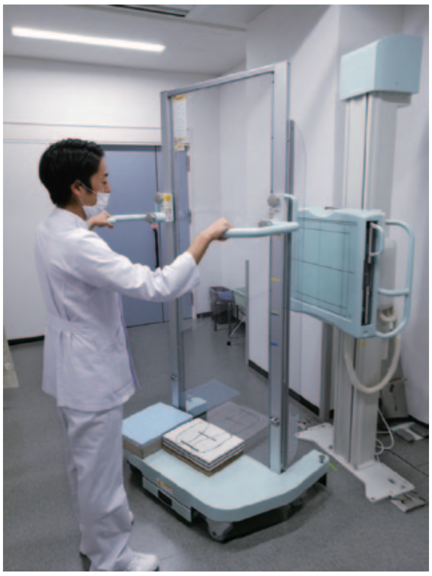


Fig.8 Fender Wall for Long View Radiography

Preparation for full-spine radiography can be completed by simply aligning the laser marker with the upper edge of the orbit for the starting point and between the legs for the end point and then pressing the set button, so that the tube and the image receptor on the Bucky stand are automatically moved to the radiography starting position. During the exposure switch is held to press, tube and image receptor movements are interlocked and radiography is finished within the approximately five seconds it takes to emit two or three exposures. Then to acquire a lateral view next, simply press the set button to immediately move the tube and image receptor to the same radiography starting point. Even long view radiography of the lower extremities can be performed more simply and quickly using almost the same procedure. A pre-view image of the full spine is displayed on the image processing monitor within about three to five seconds after exposure, so that examination results can be determined immediately. Density and contrast adjustment settings are usually already appropriate, if necessary the settings can be adjusted without taking time **(Fig. 9)**.

In our department, we have placed markings on the fender wall for long view radiography so that we can smoothly select the film size and number of exposures for long view radiography of the lower extremities without worrying about the settings **(Fig. 10)**.

When we were introducing the system, we worried that there might be problems at the seams where the images are stitched together or with body movement during the radiography, but there have been almost no such problems. Consequently, our overall impression based on efficiency and safety is that the long view radiography system is quite excellent.

6. Our Experience Using Tomosynthesis

Initially we were considering including tomosynthesis with a R/F system, but we put it hold on because of concerns that long wait times might occur during IVR examinations and that we would need to move a patient between radiography rooms and R/F room if we performed both radiography and tomosynthesis on the same day. That is exactly when we heard about the RADspeed Pro EDGE package, a general radiography system, capable of tomosynthesis.

The RADspeed Pro EDGE package is capable of tomosynthesis in both the standing and supine positions. However, standing and supine positions involve different FPD movements. For supine tomosynthesis, the cross-section height can be specified, so that the FPD moves along with the tube, but for standing tomosynthesis, the FPD remains stationary and only the tube moves. Therefore, the cross-section height cannot be specified [a]. That means the available radiography range is different in standing and supine positions, so additional care is required.

It takes about 12 seconds to acquire 60 images, the raw images are sent to the dedicated reconstruction workstation in about one minute after acquisition. Once it is sent to the workstation, the system is available for performing any other radiography, so there is no interference with other examinations.

As to the image reconstruction, the T-smart reconstruction method is very effective in suppressing metal artifacts. It has various modes for different types of metal objects in the body, such as artificial joints, metal plates, and screws. Image reconstruction processing will probably require experience and skill.

Now that tomosynthesis is available in the general radiography department, it has broadened the scope of observation and diagnostic possibilities and allowed us to provide higher quality images to patients.

(a) Frontal View of Entire Lower Extremity

(b) Lateral View of Entire Lower Extremity

Fig.9

Fig.10 Markers for Long View Radiography

7. Conclusion

At this point, after actually using the system for clinical applications for about one year since introducing the system, we are extremely pleased. It has satisfied all items on the wish list we prepared before relocating the hospital. The system seems to be developed from the perspective of technologists, making it very convenient and easy to operate. Providing high quality images and enabling shorter examination times have resulted in improved service to patients.

Given the very high cost of the FPD panel, we handle it with somewhat extra care, but presumably we will be using it for a long time.

Currently, we are focusing on reducing X-ray dose levels further, while also maintaining high image quality, so we look forward to Shimadzu offering even more improved technologies and new functionality in their products.

[a] (Editors' footnote) Cross-section height can be changed in the reconstructed Images

R/F

The detection of Scapular Notch with Tomosynthesis after Reverse Shoulder Arthroplasty —12th CAOS Japan Annual Meeting—

Yoshihiro Hirakawa, M.D.,Ph.D.

Department of Orthopaedic Surgery, Osaka City University Graduate School of Medicine[1], Ito Clinic, Osaka Shoulder Center[2]

Yoshihiro Hirakawa[1] (currently at Osaka Social Medical Center), Tomoya Manaka[1], Yoichi Ito[2], Yukihide Minoda[1], Koichi Ichikawa[1], and Hiroaki Nakamura[1]

At the 12th CAOS Japan Annual Meeting held in Osaka on March 22 to 23, 2018, Yoshihiro Hirakawa, M.D.,Ph.D. from the Department of Orthopaedic Surgery at Osaka City University Graduate School of Medicine (currently at Osaka Social Medical Center) gave an academic presentation about tomosynthesis using a Shimadzu SONIALVISION G4 fluoroscopy system, entitled "The detection of Scapular Notch with Tomosynthesis after Reverse Shoulder Arthroplasty" This article provides an overview of that presentation.

1. Purpose

One of the complications that can occur from reverse shoulder arthroplasty (RSA) is scapular notch. Scapular notch is a complication that the liner inserted in the humerus and the scapula are worn out due to their repeated collision during shoulder joint movement. Commonly reported scapular notch is caused by collision between the liner and the lower part of the scapula due to the adduction of the humerus. The bone defect below the scapula can be detected with the frontal XP image of the shoulder joint. In contrast, anterior and posterior scapular notch can occur when the liner inserted in the humerus repeatedly collides the scapula during internal and external rotation of the humerus. However, if anterior and posterior scapular notch occurs, the notch cannot be detected with the frontal XP image of the shoulder joint. Furthermore, the scapular notch near the base plate or screws cannot be detected with the CT image due to metal artifacts.

In recent years, tomosynthesis has been reported as an effective method of detecting bone defects.[1)] Because tomosynthesis can be used to obtain tomography images with less metal artifacts, tomosynthesis offers the possibility of detecting anterior and posterior bone defects that is difficult to detect with XP or CT images.

The purpose of this study is to compare the detection sensitivity and specificity of bone defects around the RSA base plate in pig scapula with XP, CT and tomosynthesis images.

2. Method

2.1 Surgery Method

A DePuy Synthes Delta Xtend™ system was used for RSA on four pig scapula. A control model, anterior bone defect model, posterior bone defect model, and inferior bone defect model were prepared **(Fig. 1)**. No bone defect was made to the scapula in the control model. In the anterior, posterior, and inferior bone defect model, a bone defect was made to the depth where the screw was exposed. A standard 27 mm-diameter base plate was inserted in each model and fixed with four screws. Then a 38 mm-diameter standard glenosphere was installed in each model and fixed with screws. To simulate the state of osteolysis, the bone defects were filled with 1 % agarose gel simulating granulation tissue.

2.2 Evaluation Method

Images of each model were acquired with XP, CT (with metal artifact reduction), and tomosynthesis. Shimadzu's dual linear drive method was used to acquire tomosynthesis images and the T-smart method for reconstructing images was

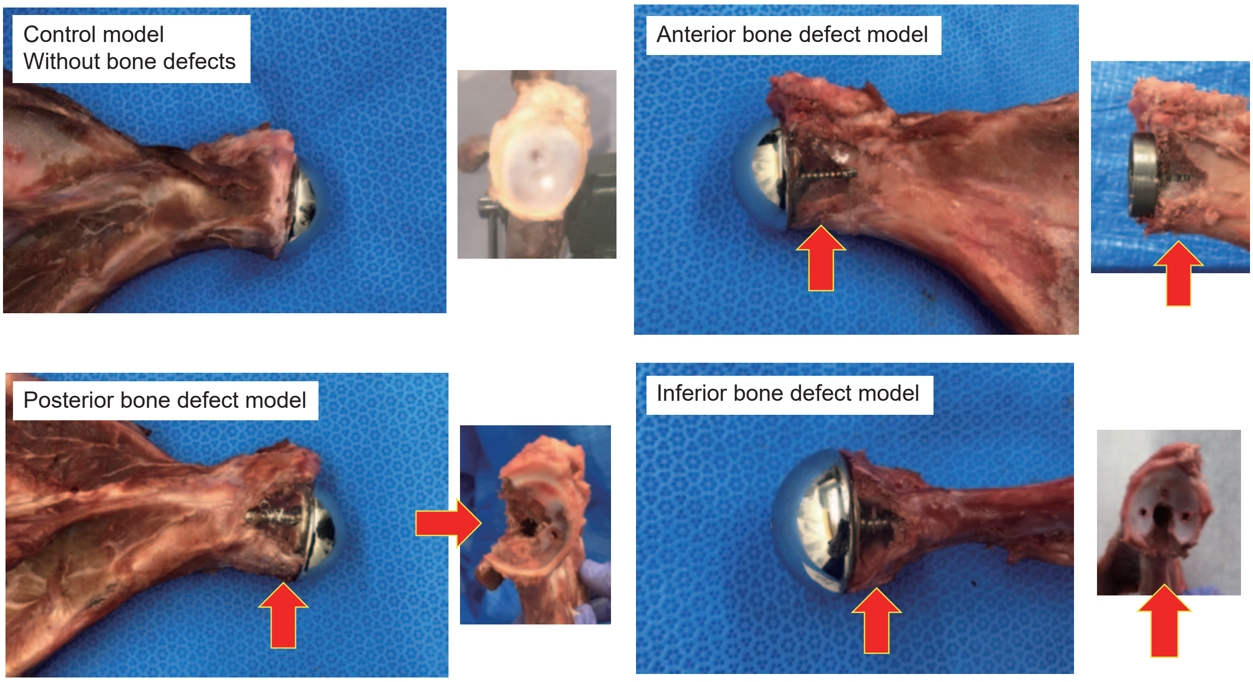


Fig.1 Bone defect Models Made from Pig Scapula

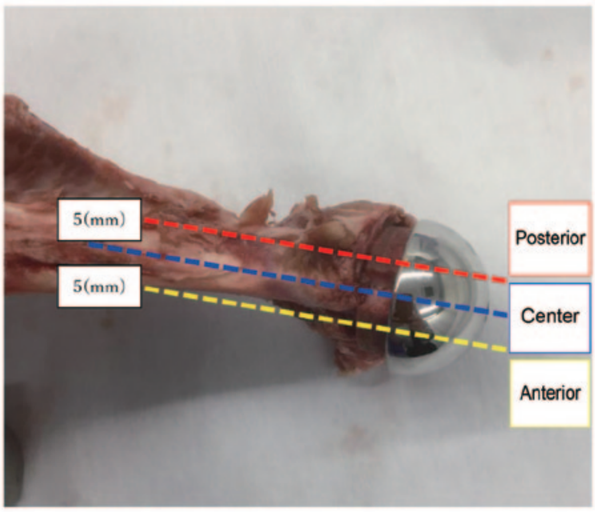


Fig.2 Slice Positions in Tomosynthesis Images

used to reduce metal artifacts. A total of three tomosynthesis slices were evaluated **(Fig. 2)**, with a slice at the 5 mm anterior side from the center peg, a slice at the center peg position, and a slice at the 5 mm posterior side from the center peg. The frontal image was used with XP. CT image slices were acquired at 1 mm pitches, so that all bone defects around the base plate would be shown, and the coronal image was used for evaluation. The evaluation of bone defects was performed by explaining each model to 12 orthopedic surgeons in advance and then having each surgeon look at images with the corresponding model name hidden and deciding whether or not the images matched the respective models. The detection sensitivity and specificity were calculated assuming the image-based evaluation is similar to an examination and the presence of bone defects in each model shows actual bone defects in patients.

3. Results

With determination based on XP, both sensitivity and specificity were 100 % for the inferior bone defect model, but detection sensitivity was a low 25 % and 9 % for anterior and posterior bone defect models, respectively. That result suggests that XP can only be used to detect inferior bone defects **(Fig. 3)**. With determination based on CT, bone defect detection was low due to screw and base plate metal artifacts, with bone defect detection sensitivity 58 % for the control model, 25 % for anterior bone defect model, 33 % for posterior bone defect model, and 50 % for inferior bone defect model **(Fig. 4)**. In contrast, tomosynthesis clearly showed the outline of both anterior and posterior bone defects, indicated by red arrows in **Fig. 5**, with bone defect detection sensitivity a high 83 % for both anterior and posterior bone defects. Sensitivity and specificity for all models are indicated in **Table 1**.

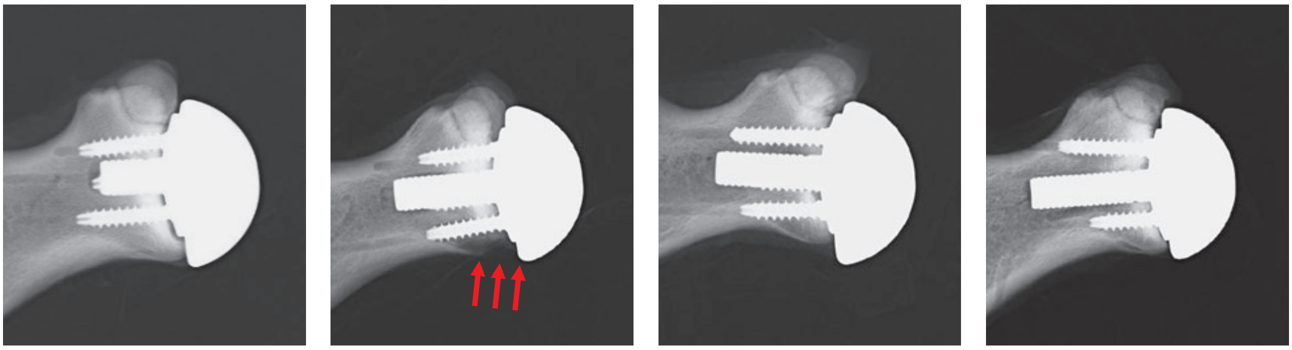

Control model | Inferior bone defect model | Anterior bone defect model | Posterior bone defect model

Fig.3 XP Images

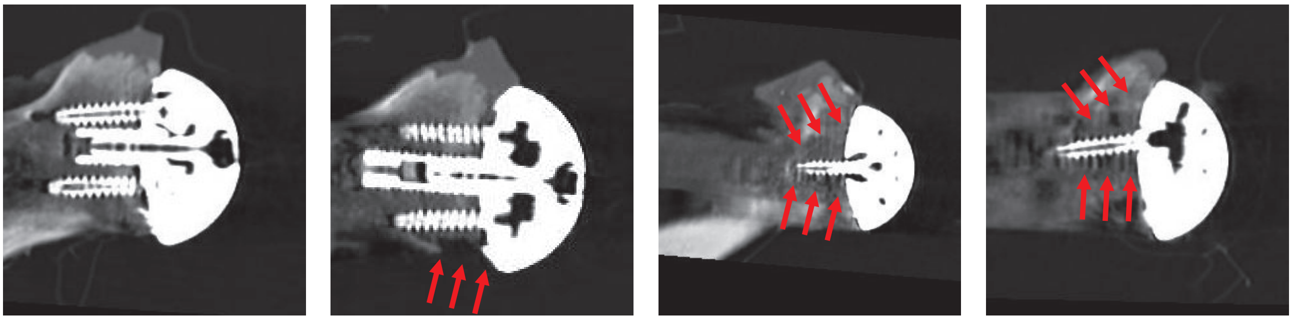

Control model | Inferior bone defect model | Anterior bone defect model | Posterior bone defect model

Fig.4 CT Images

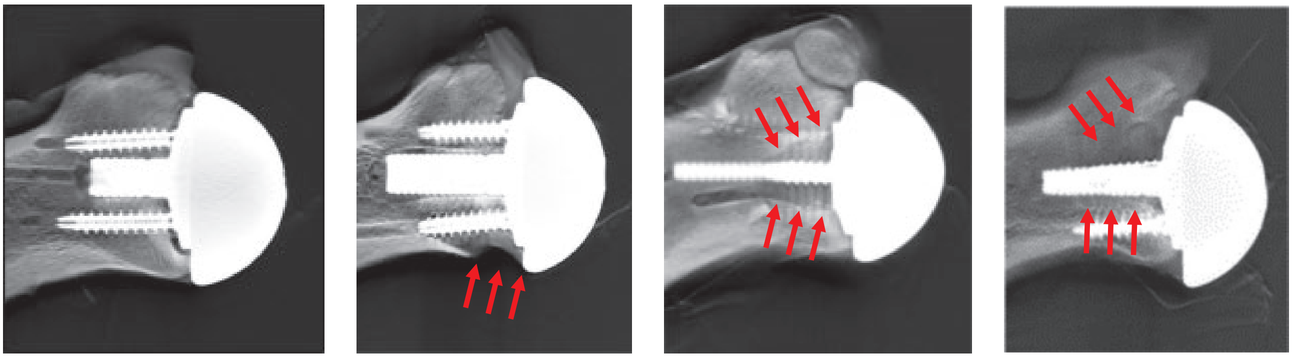

Control model | Inferior bone defect model | Anterior bone defect model | Posterior bone defect model

Fig.5 Tomosynthesis Images

Table 1 Sensitivity and Specificity for All Bone Defect Models

		Sensitivity	Specificity
XP	Control	42 %	89 %
	Anterior bone defect	25 %	100 %
	Posterior bone defect	9 %	94 %
	Inferior bone defect	100 %	100 %
CT	Control	58 %	83 %
	Anterior bone defect	25 %	83 %
	Posterior bone defect	33 %	81 %
	Inferior bone defect	50 %	83 %
Tomosynthesis	Control	75 %	92 %
	Anterior bone defect	83 %	94 %
	Posterior bone defect	83 %	94 %
	Inferior bone defect	100 %	100 %

4. Discussion

Scapular notch has been reported as a complication after RSA surgery. Given that scapular notch has been reported to affect long-term clinical results[1), early detection of scapular notch is important in clinical practice. The results confirm that XP is more than adequate for detecting inferior bone defect, which provides 100 % detection sensitivity. However, anterior and posterior bone defect models could not be distinguished from the control model in XP images, making it difficult to detect bone defects with XP. In CT images, it was difficult to evaluate bone defects because of significant metal artifact effects resulting from the proximity of the bone defects to the base plate and screws. In contrast, tomosynthesis can produce tomographic slices at any location, either anterior, center, or posterior from the peg with less metal artifacts, making it possible to detect anterior and posterior bone defects. Based on the results above, tomosynthesis was found to be very effective for evaluating anterior and posterior bone defects in scapula.

For total knee arthroplasty, tomosynthesis has been reported as an effective method of detecting initial bone defects around implants.[2)] The advantage of tomosynthesis is that it can provide any tomographic images without significantly higher medical care cost and X-ray dose than XP and with far less X-ray dose and less metal artifacts compared to CT.

5. Summary

This study showed that tomosynthesis is extremely useful as an examination method for detecting scapular notch after RSA surgery.

References:

1) Brent Mollon et al.,Impact of scapular notching on clinical outcomes after reverse total shoulder arthroplasty: an analysis of 476 shoulders. Journal of shoulder and elbow surgery.26,1253-1261.2017

2) Yukihide Minoda et al.,Detection of small periprosthetic defects after total knee arthroplasty. The journal of arthroplasty 29. 2280-2284,March.2014

FLEXAVISION F3 package USERS' VOICE
Portable FPD Package
Sendai Nishikicho Clinic (Miyagi Prefecture)

"A" Score Received from Chest X-Ray Examination Quality Control Survey! High Marks for Image Quality

Radiological Technologist
Osamu Onodera, R.T.

Supporting the Health of Local Citizens and Corporate Employees

Ever since our clinic opened in the Aoba ward of Sendai in 1984, we have been providing general internal medicine services, such as managing lifestyle diseases (diabetes, hypertension, etc.) and other chronic conditions and treating respiratory disorders. In addition, as an occupational health screening center, we are also involved in diagnosing and treating conditions assumed to be caused by work (occupational illnesses), supporting the application process for receiving worker' compensation and the corresponding recovery, providing advice for reintegration into society, and so on.

In Addition to Fluoroscopic Screening of the Stomach, Also Very Actively Involved in Chest Radiography

Originally, the clinic was operated from a two-story wooden building, but we moved to the current building as a tenant in 2015.

The main issue at the time, when we were moving, was how to prepare a one-floor environment where we could perform respective examinations as efficiently as possible. The FLEXAVISION F3 ("F3" below) R/F system's small number of components, space-efficient design, and ability to perform chest radiography with a portable FPD were a good fit for the space limitations of our clinic.

Rather than introducing a general radiography system, we use the F3 to perform about 400 fluoroscopic stomach screening examinations and 1700 chest X-rays per year. Given that a single radiological technologist performs both types of examinations, the system layout was optimized to ensure examinations can be performed smoothly.

Chest Radiography Accomplished in a Limited Space

The F3 offers an X-ray tube swiveling mechanism that enables 90 degrees of rotation (optional), which we use in combination with a Bucky stand, so that the system can be operated similar to a general radiography system. Since the layout at our clinic eliminates the need to move the Bucky stand, it is easy to set up and there is no worry about misalignment. Even when I am not available, doctors can perform chest radiography without any inconvenience. Of

course, chest radiography could also be performed on the R/F table, by using the functionality for extending the SID value to 1.5 m, but pneumoconiosis screening requires an SID of 1.8 m or more, which made it essential to use the system in combination with the Bucky stand. Chest radiography using the Bucky stand enables contact radiography with the shoulder blades in a sufficiently open position, which offers the advantage of positioning the patient in a stable posture that places less burden on the patient.

※These switches on the collimator operate the imaging unit (X-ray tube and FPD).

X-ray tube longitudinal movement switches are provided on the collimator, so that even without a local control console, the tube can be positioned easily while also providing patient care. Given that a single technologist performs the setup process at our clinic, the switches have increased our examination efficiency, which has been very helpful.

Furthermore, we are very satisfied with the image quality, which has been adjusted for pneumoconiosis screening.

■ "A" Score Received from Chest X-Ray Examination Quality Control Survey

The Chest X-Ray Examination Quality Control Survey is conducted each year by the National Federation of Industrial Health Organization for the purpose of evaluating chest X-ray radiography technique and image reading skill. It involves submitting images for three patients. If two of the three sets of images receive an "A" score, then an overall "A" score is given.

Our clinic submitted images for the first time in 2017, which resulted in an "A" score for all three sets of images.

平成29年11月20日

精度管理調査評価結果通知書
【胸部エックス線検査分野】

全国労働衛生団体連合会
総合精度管理委員会

【胸部エックス線画像の
審査結果は　評価　A】に
なりましたので通知します。

■ Fully Utilizing the Large 14 × 17-inch Size FPD

In addition to screening exams, we also perform radiography of the cervical spine and lumbar spine as part of group health screenings for new recruits before they start working at companies.

For such examinations, where we use the oblique projection function with the patient lying on the R/F table, the fact that the exposure position can be confirmed with fluoroscopy before starting radiography is quite convenient. The system also enables radiography of the abdomen, paranasal sinuses, and hands, where the large 14 × 17-inch field-of-view provides flexibility for accommodating a wide variety of exposure situations without worrying about insufficient field-of-view size.

Advice to Doctors Considering Introducing This System

In addition to the compact design that fits easily even in confined spaces, the great image quality that is comparable to a dedicated system, and user-friendly functionality for general radiography, function it also offers simple operability that ensures it can be operated easily by anyone in an emergency.
Furthermore, it is comforting to know that the image quality can be adjusted to user requirements, such as for pneumoconiosis screening at our clinic.

Stories of Kyoto-born Masterpieces — ⑳

Numerous outstanding products have helped shape the history of Kyoto — here we outline the stories hidden behind them.

For the *ohari-bako*, a sanada braid is passed through the box during its creation to prevent any wobbling. As the stunning grain patterns are difficult to attain, the number of large boxes that can be created is limited.

Kiribako — Paulownia wood boxes

Wood from the paulownia tree has long been used in Japan. Artifacts unearthed at the ancient Toro archaeological site in Shizuoka — comprising a village settlement and rice paddy remains from the Yayoi period (c. 300 BCE - 250 CE) — have included *koto* stringed instruments and *tageta* work sandals made from paulownia wood. Other evidence of the paulownia tree's use can be found in the treasures stored in the Shosoin Repository, such as in *gigaku* masks and modern *Shiragi-koto* stringed instruments. Such wide use of the material is testament to its unique qualities.

Paulownia wood has very large pores, and it is said to be the lightest wooden material in Japan. Its light weight makes it easy to carry, while its softness means it is highly workable — one reason it is used even now in the bodies of stringed instruments such as *koto*. The wood is also able to maintain a constant level of humidity, and therefore has been widely used to store and protect personal treasures. In fact, this is the very reason why hanging scrolls and bowls used in the tea ceremony are kept in these in *kiribako*.

In Kyoto, requests for *kiribako* were said to differ between the east of the Kamogawa river and the west. On the east of the river were Kiyomizu ware potters and wholesale merchants who primarily required *kiribako* to hold their produce; in Muromachi and Nishijin on the west, however, home to numerous kimono merchants, were weavers who required *kiribako* for their woven goods. Although work between the east and west does not differ now, it is fascinating to think that products were once catered to location.

Akunuki determines the quality of the wood

As mentioned above, *kiribako* are perfect for keeping or storing objects. The reason Paulownia wood is so easy to work with, however, is the uniformity of its material properties — a feature which is partly down to the preparation process. Paulownia wood contains a large amount of tannin and is rich in lye, and so must be left exposed to wind and rain for three years after it is cut. The wood absorbs rain when left in the sunlight, and when it dries, the tannin is drawn out of the wood. Repeating this process, known as *akunuki*, removes the lye, and ensures the wood does not easily warp.

When the wood has dried, it is made into lumber. One result of removing the lye from the wood is a blackish color, but this is easily shaved off to reveal a beautiful surface. From there, the wood is cut to appropriate thicknesses and sizes to suit its purpose, a process that requires the expert skill of the woodworker. For example, wood for large garment boxes — to

The boxes are coated with *tonoko* to finish. The majority of *tonoko* is created in Kyoto's Yamashina district.

The paint is applied with one hand, and then spread with the other while drawing the illustration. The methods and tools used by each artist are different. Illustrations can be tailored to the customer's request, and many choose to decorate their boxes with plants and flowers.

Wood that has been dried is taken to the workshop. If the woodworkers pick up the paulownia wood and determine it hasn't been exposed to enough sunlight, it is dried once again on the rooftop.

The adhesive is uniformly tapped onto the box using a special spatula. Once the adhesive has been applied, it is kept in place by a thick rubber band to dry.

Illustrations are drawn onto the side of the *ohari-bako* so that the lid isn't put on back to front; the lid is put on correctly when the illustrations align.

hold kimono fabrics, for example — mustn't be cut too short to maintain the long beautiful grain; wood for smaller boxes can be cut shorter to display a short grain; and the most beautiful grain pattern must of course be left for the box lid. Each cut of the wood has a specific purpose, and only the expert eyes of the woodworker can make the most of the limited wood available, and bring out its true beauty.

Once the wood has been divided, it is joined together at 90-degree angles to create a frame. In order that it maintains a high level of strength and blends seamlessly into the wood, the adhesive used is a mixture of starch glue and wood glue. In the summer, it can dry in four to five hours, while in the winter it takes a little longer and is thus left overnight. Once dry, the bottom and lid are fixed onto the frame, before the surface is smoothed with a plane. To finish, the wood is coated with *tonoko*, weathered clay which has been pulverized into powder. Not only does *tonoko* serve to bring out a wonderful texture, it also prevents finger marks and oil damage.

Seamless lids and stunning illustrations

Located near Nishi Hongan-ji Temple, Hakotou Shoten, a manufacturer of *kiribako*, was founded in 1891, and fifth-generation owner Ryuichi Yamada is now at the helm. Although it was first involved in the wholesale of *kiribako* for kimono fabrics, Hakotou Shoten established a showroom and moved into retail in the year 2000 to counter a stagnating market. Their most popular products now are *tamago-bako*, or egg-shaped boxes, whose rounded, smooth shapes are decorated with charming illustrations. At first glance unnoticeable, the boxes slide open at a jagged edge, much like those found on a real cracked egg. "The rounded form of the *tamago-bako* and the jagged edge at which it opens are down to the delicate techniques of the craftsmen," says Yamada. Similarly, the lids of the *ohari-bako* boxes seamlessly connect to the body. "We first create a box without an opening from a single piece of wood, after which we split the top and bottom, smooth them down with a plane, and polish them with sandpaper." The lid and body are so expertly put together that the line at which they connect is almost invisible, one reason why the lid won't close when put on back to front. This precise structure is not all; skilled Japanese artists are put in charge of the beautiful illustrations. "The illustrations can be tailored to the customer; we want them to be able to enjoy their very own, unique *kiribako*." Paulownia wood boxes are not limited to outstanding storage capabilities — Hakotou Shoten is further expanding its clientele with *kiribako* beauty.

Special thanks to: Hakotou Shoten http://www.hakotou.co.jp/

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6032-08801-12BTD
ISSN0916-8745