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Vascular

Endeavors in Using 3D Images in Crossover Intervention —Arrhythmia Treatment

Utilizing Trinias in Catheter Ablation for Atrial Fibrillation

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1. Introduction

The national health insurance has been covering the charge of catheter ablation in Japan since 1994. The indications for the catheter ablation have been spreading to almost all of arrhythmias since then, and the number of catheter ablations performed is rising dramatically as with the other catheter interventions of the cardiovascular system. In the last few years, our hospital has also seen a large increase in cases across all cardiovascular diseases indicated for catheter ablation, which has prompted the hospital to improve its angiography systems and to procure Shimadzu's Trinias B12 unity edition angiography system (hereinafter, Trinias unity edition). This article provides an overview how we apply Trinias unity edition for the catheter ablation and the characteristic features of the system.

2. Catheter Ablation for Tachyarrhythmia in Japan

In the early days, the only imaging modalities that displayed the position of the catheters were diagnostic X-ray systems intended for angiographic image, which was not competent for accurate lesion mapping of arrhythmic foci was. Then all kind of arrhythmias has not been candidate for catheter ablation, and limited arrhythmias which do not require contiguous or deeper lesion were able to be indicated for this procedure. At that day, an atrial fibrillation has been known to be the most common arrhythmia that increases in prevalence with age and is somewhat known for affecting celebrities, which had been unfortunately adopted for the catheter ablation as a matter of course.
In 1991, it was reported that the atrial fibrillation could be cured by making incisions in the atria by open heart surgery[1], which required accurate and contiguous incisions and the idea of a catheter-based management of the atrial fibrillation was still a distant dream.

3. Catheter Ablation for Atrial Fibrillation

In 1998, it was reported that the atrial fibrillation can be initiated by the spontaneous firing originating from the pulmonary veins[2], which could be treated with the electrical blockade between the pulmonary veins and the left atrium by the catheter ablation. Since then, this led to a dramatic increase in numbers of cases indicated for treatment by the catheter ablation. Since the year 2000, magnetic fields have also been applied to render the position of catheters in the three dimensional image, the outcomes regarding catheter ablations have been improved dramatically, and many facilities are now able to perform catheter ablations to various kinds of arrhythmias including the atrial fibrillation. Nevertheless, there is still no established method to treat longstanding persistent atrial fibrillation with catheter ablation, and lots of researches have been underway into methods beyond isolating the pulmonary veins.
Recently, a wider pulmonary vein isolation has been reported to obtain a better recurrence rate, and the pulmonary veins isolation including the posterior wall of the left atrium, i.e., a box PVI has also proposed as a good option for the various types of atrial fibrillation ablation. In our hospital, we perform the box PVI in all atrial fibrillation cases and have achieved the better outcome than before. However, the box PVI is known to be more difficult to attain, because the accurate information of the position of the catheter must be indispensable for the procedure. Current 3D mapping systems have been providing the position of the catheter with very high accuracy but hardly complementing the catheter movement arising from not only respiratory and cardiac motion but also patient movement, which can elicit errors of the positions. Safer and more accurate ablations should require more precise assessment of the catheter position within the heart, and the only angiography systems can be an option for complementing the abovementioned errors. However, it must be aslo important to minimize the radiation exposure.
As mentioned above, operators performing catheter ablation need to know the position of the catheter in 3D within the left atrium. Our newly procured Trinias unity edition can visualize the catheter with extremely

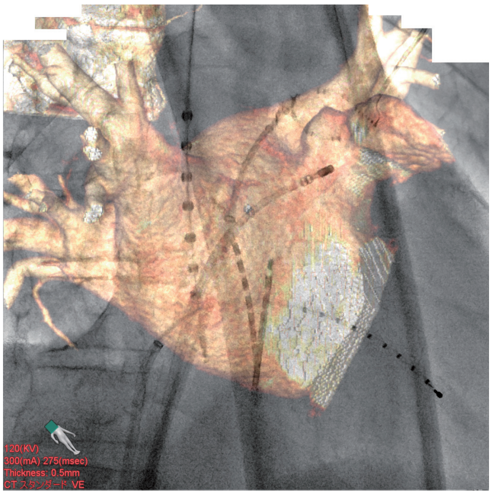

Fig.1

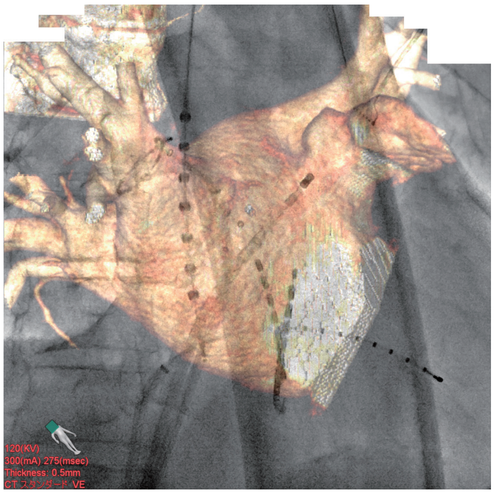

Fig.2

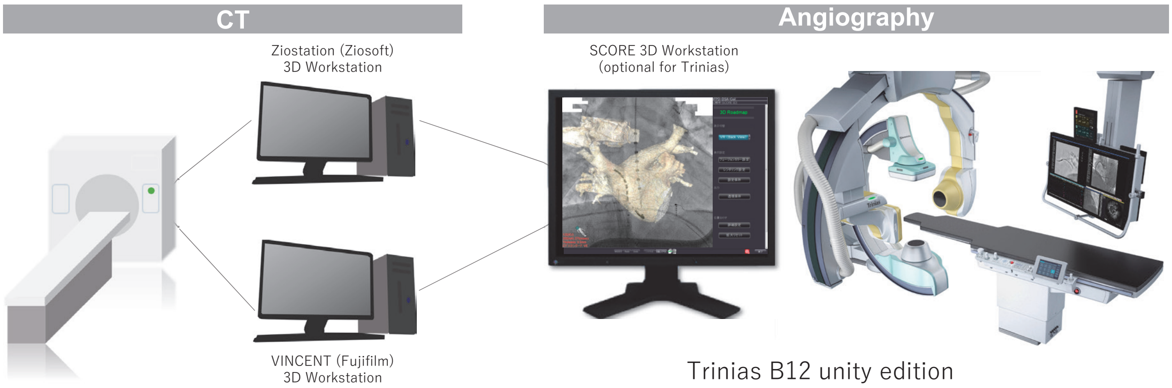

Fig.3

low dose fluoroscopy, and its SCORE Navi+Plus also can overlay these fluoroscopic images with a reconstructed 3D image of the patient obtained during preoperative CT. This shows us the position of the catheter within the reconstructed 3D image precisely and gives us the same feeling of control as a dedicated 3D mapping system designed for ablation.

Previously in our hospital, ablation procedures were performed with an angiogram of the left atrium (reference image) on one screen and fluoroscopic images of the catheter on another screen. This forced the operator to look between the two screens to verify the position of the catheter inside the heart (left atrium).

Now, SCORE Navi+Plus overlays fluoroscopic images of the catheter onto the reconstructed 3D image obtained by preoperative CT and presents this as a single image. Free of the need to look between two screens, operators are now better able to concentrate on the operating field and accurately assess the position of the catheter. Also, because responsibility for spatially aligning the realtime fluoroscopic images on the reconstructed 3D image (image registration) can be handed off to a radiological technologist, operators can give their full attention to the procedure at hand. As shown by **Fig. 1** and **Fig. 2**, catheters can be manipulated safely and without difficulty following the shape of the heart.

Our hospital can create the reconstructed 3D images obtained by preoperative CT on either of two workstations: a VINCENT (Fujifilm) and a Ziostation (Ziosoft) workstation. Thankfully, SCORE Navi+Plus can connect and communicate with either workstation so both can be used in ablation procedure to create reconstructed 3D images for SCORE Navi+Plus **(Fig. 3)**. This compatibility of SCORE Navi+Plus with different workstation manufacturers demonstrates the expandability and user-friendliness of SCORE Navi+Plus.

Conclusion

This article outlines how we use Trinias in catheter ablation for atrial fibrillation.

Trinias unity edition is an angiography system that enables us to accurately track the position of the catheter in three dimensions with extremely low exposure doses both safely and while causing less stress to the patient—features not available from popular dedicated 3D mapping systems for catheter ablation. We are convinced that Trinias unity edition will help improve outcomes in arrhythmia treatment.

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Vascular

Approach for Crossover Interventional Procedures Using 3D Imaging —Neurosurgery

Trinias Performance in Coil Embolization for Intracranial Aneurysm

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1. Overview

Kozoji New Town was developed as a commuter town of Nagoya City and stands alongside Tama New Town and Senri New Town as one of the three major "new town" development projects in Japan. Nagoya Tokushukai General Hospital was opened adjacent to Kozoji New Town in June 1986. As a core hospital with 350 beds, it is the 16th hospital opened by the Tokushukai Medical Group and their first hospital in the Chubu region of Japan **(Fig. 1)**. The Department of Neurosurgery plays an important role in providing medical care for stroke syndrome, which can justifiably be called a national affliction, for the increasingly elderly residents of Kozoji New Town.
Our department provides surgical treatments for a variety of cerebrovascular disorders, but due to the recent trend for minimally invasive surgery that places a smaller burden on the patient, we are seeing an increasing shift in emphasis away from open surgery and towards endovascular therapy.
Given this trend, in addition to our Hybrid Operating Room and First Catheterization Room, in May 2019, we also procured a Shimadzu Trinias B12 unity edition angiography system (hereinafter called as "Trinias unity edition") for our Second Catheterization Room.
Our department started using Trinias unity edition in May 2019 and has since used it to treat a variety of cases including coil embolization for intracranial aneurysm, embolization for AVF and AVM, embolization of tumor feeding vessels, and carotid artery stenting (CAS) for carotid artery stenosis.
Of these endovascular interventions, this article reports on our experiences using Trinias unity edition for coil embolization for intracranial aneurysm.

Fig.1 Nagoya Tokushukai General Hospital
Relocated to a new site in April 2014

2. Trinias Performance in Coil Embolization for Intracranial Aneurysm

2.1 SCORE PRO Advance

When coil embolization first started being used to treat intracranial aneurysms, cases that required angioplasty such as wide-neck aneurysms and fusiform aneurysms could still often only be treated by craniotomy and clipping surgery. However, thanks to balloon-assisted coiling and stent-assisted coiling, intracranial aneurysms previously only treatable by clipping surgery can now be treated by coil embolization.
Compared to coil embolization performed using simple techniques, balloon-assisted and stent-assisted coil embolization brings a number of noted issues, including difficulty visualizing the complex intermingling between the coil-delivering microcatheter and stent- or balloon-delivering catheter, and difficulty verifying balloon dilation or stent expansion.
Trinias unity edition comes equipped with SCORE PRO Advance that provides motion-tracking noise reduction, in addition to high-speed image processing that was developed based on the key concepts of a lower X-ray dose and high image quality. By using SCORE PRO Advance, Trinias unity edition ensures high visibility of medical devices during coil embolization procedures.
Here we present the case of a 67-year-old woman who was discovered incidentally to have an unruptured intracranial aneurysm in the parasellar region of the right internal carotid (IC) artery during a medical checkup of the brain. We identified a wide-necked

aneurysm with a 5-mm neck width and 6-mm dome and performed balloon-assisted coil embolization.

After placing a guiding catheter (8Fr Optimo, Tokai Medical Products) in the internal carotid artery and using remodeling technique with a SHOURYU HR balloon catheter (Kaneka), coil embolization for the intracranial aneurysm was completed without issue by inserting an AXIUM coil (Stryker) through SL-10 (Stryker) into the aneurysm.

Trinias unity edition carries out motion tracking noise reduction by detecting and aligning subject movement for specific regions within time-sequential moving images to reduce noise without causing after-image. This motion tracking noise reduction enables us to verify with extreme clarity the expanded balloon, balloon marker, and 1st and 2nd microcatheter markers, even in the parasellar region with its complex bone structure and large volume of air **(Fig. 2)**.

Furthermore, though difficult to see in still images, Trinias unity edition keeps catheter after-image caused by vessel pulsating to a minimum, thereby allowing us to recognize even minute catheter movements within the aneurysm that are caused by balloon inflation and deflation.

2.2 FluoroMAP Function

The next case is a 44-year-old woman with a ruptured aneurysm in the parasellar region of her right internal carotid artery caused by a subarachnoid hemorrhage.

The aneurysm neck width was 2 mm and the long and short axes of the aneurysm dome were 4 mm and 2 mm, respectively. Similar to the previous case, we chose to perform balloon-assisted coil embolization.

When a relatively small aneurysm is treated by coil embolization, proper care and attention are needed to avoid the coil escaping from aneurysm. However, for aneurysms in this region, the surrounding bone structure and air in the nasal sinus and petrous bone make it difficult to ascertain the location of the catheter tip, markers, the state of the coil, and balloon expansion, which causes substantial anxiety during coil insertion over whether the coil has NOT escaped from the aneurysm.

Trinias unity edition comes with a range of roadmap functions. The FluoroMAP function substantially improves device visibility in the roadmap by applying a subtraction processing to fluoroscopic images and using the resulting image as a MAP image.

The FluoroMAP function images with the bone subtracted from the image, reducing significantly the issues associated with device visualization **(Fig. 3)**.

2.3 SCORE 3D

Trinias unity edition can perform 3D imaging by C-arm rotation speed at 60°/sec and can display high-definition 3D images just 15 seconds after image acquisition.

In a final case, a patient suffered regrowth and rupture of an aneurysm after initial coil embolization, but using high-definition 3D images enabled us to perform an additional and successful coil embolization.

The 40-year-old man underwent coil embolization at our hospital for subarachnoid hemorrhage associated with rupture of the anterior communicating artery and was discharged to home for outpatient follow-up with a modified Rankin scale (mRS) of 0.

Examinations performed during follow up revealed blood flow within the aneurysm due to aneurysm growth, and the patient was admitted to undergo an additional coil embolization.

Upon acquiring a 3D image from the left internal carotid artery, we confirmed a free space in the dorsal wall of the aneurysm and blood inflow associated with aneurysm growth. A SCORE 3D workstation was used to apply “see-through processing” to the blood vessels, determine in detail the relationship between the free space and parent blood vessel, then use fusion image of fluoroscopy images and 3D image to carefully apply a coil to the free space and perform a

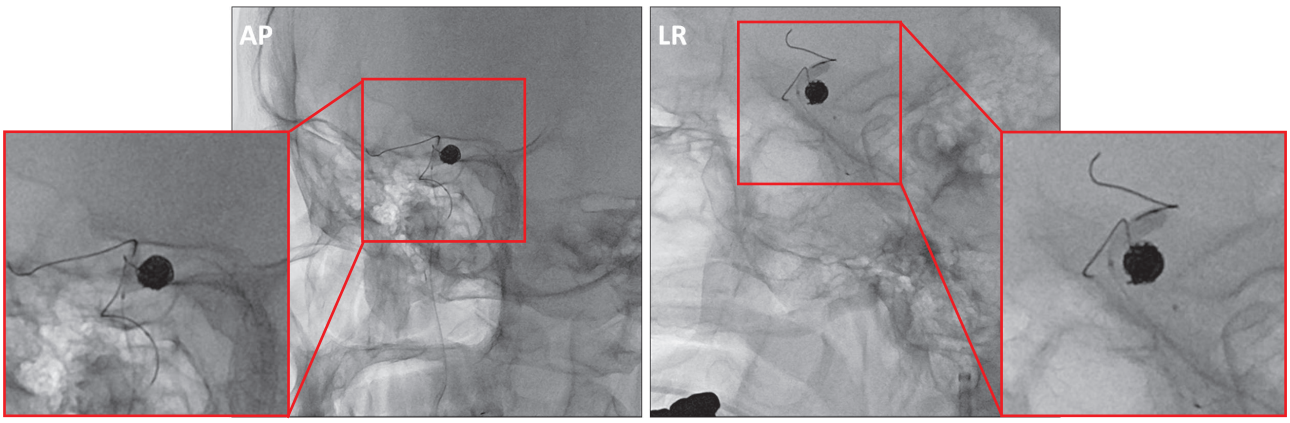

Fig.2 Performing balloon-assisted coil embolization for an unruptured intracranial aneurysm in the parasellar region of the right ICA

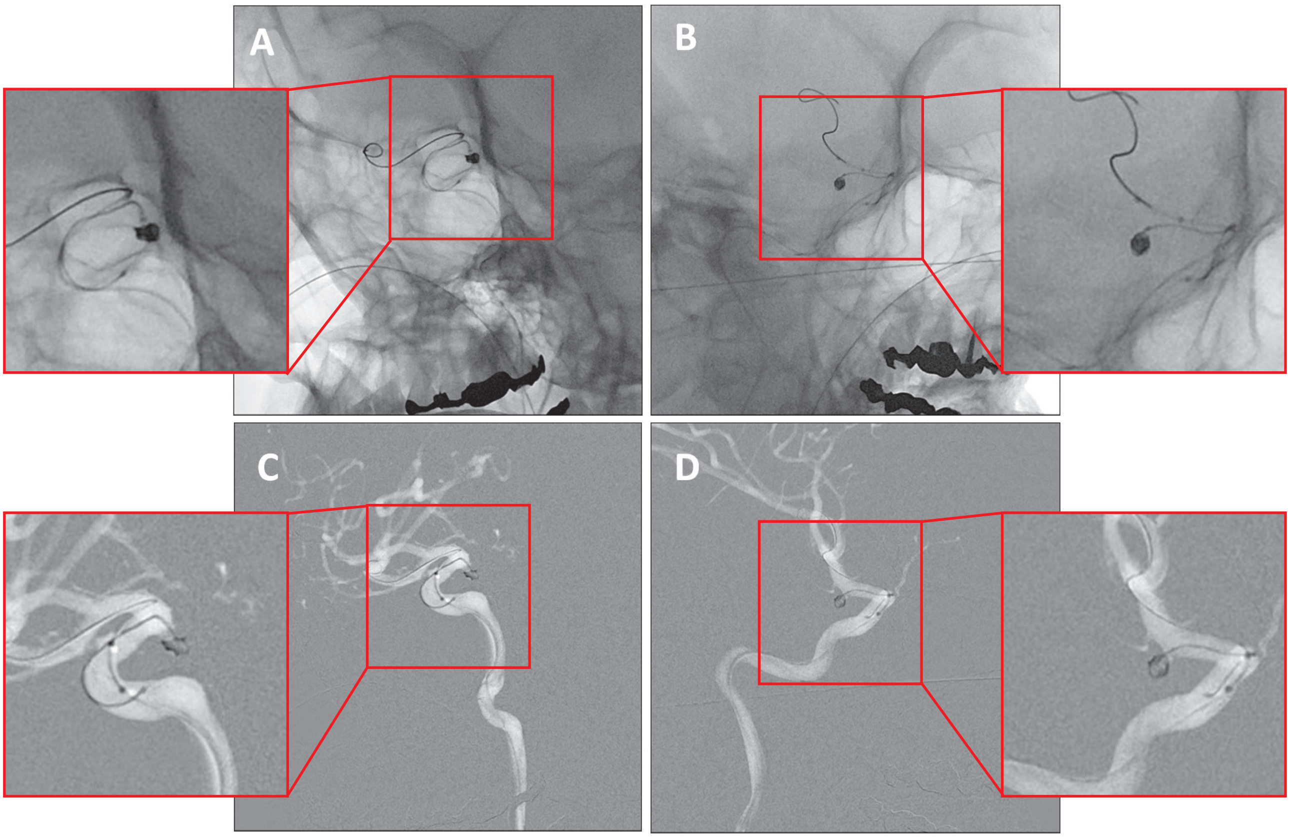

Fig.3 Performing balloon-assisted coil embolization for a ruptured intracranial aneurysm in the parasellar region of the right ICA
A, B: Original images
C, D: Images with bones removed by FluoroMAP function

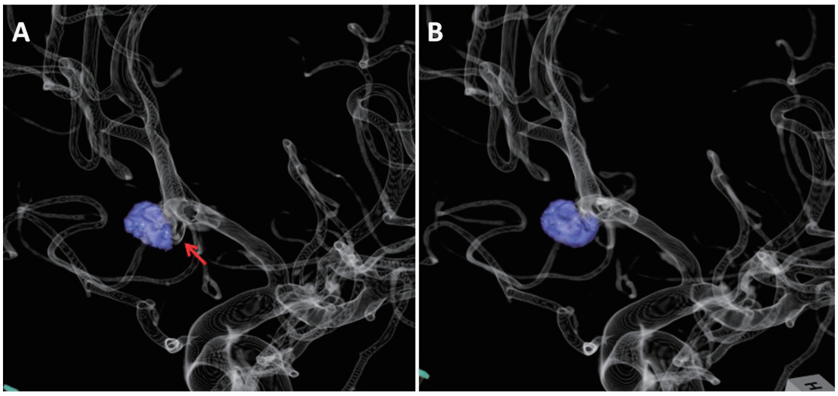

Fig.4 SCORE 3D workstation images of anterior communicating artery intracranial aneurysm
Performing an additional coil embolization for aneurysm regrowth after performing an initial coil embolization for a ruptured communicating artery.
A: Before the additional coil; space caused by aneurysm regrowth (white arrow)
B: After the additional coil

successful coil embolization **(Fig. 4)**.
As operators, we are very grateful for this ability to create high-definition 3D images by a single action in a short period of time, as it eliminates the need to wait for images during procedures and helps us to perform procedures with reduced stress.

3. Future Prospects

With a variety of different devices being developed for neurointerventional treatment, medical care is likely to continue its trend away from open surgery towards minimally invasive endovascular therapy. This will require medical institutions to update their medical devices and adopt new operatinal methods, and fully featured hardware will also be essential to make full use of the new equipment and practices. In this respect, we anticipate Trinias unity edition will play a major role at our hospital for years to come as essential hardware that supports endovascular therapy.

Vascular

Reason Why I Became a Fan of Using SCORE Chase for EVT

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Yoshito Yamamoto

1. Introduction

The Iwaki City Medical Center is located in Iwaki City at the center of Hamadori area of the Pacific coastal area of Fukushima Prefecture. Only we have the tertiary emergency medical care center in that area, and our hospital plays an important role in an acute medical care. With 700 inpatient beds, 10 ICU beds, and 20 ECU beds, we accept over 4,500 emergency cases transported to the hospital each year.
The Department of Cardiology has over 40 years of experience since it started cardiac catheterization procedures in earnest in 1974 and offers the most experienced and advanced procedures throughout the Tohoku Region, which includes almost the entire northern portion of Japan's largest island. The hospital covers a region from the Hamadori area in Fukushima Prefecture to the northern part of Ibaraki Prefecture and other surrounding areas, which has a population of about 500,000 people. An advanced emergency and critical care center is attached, therefore many patients from acute phase to chronic phase come. The facility is also certified to perform a wide variety of treatment method, making it one of the few hospitals in the Tohoku Region that can offer advanced procedures.

Percutaneous Coronary Intervention (PCI)

The center is one of the hospital that has the large number of cases and has approximately 600 PCI cases per year. About 150 cases of those cases are acute myocardial infarctions (AMIs).Nowadays we use drug-eluting stents (DES) that is coated with immunosuppressant drug. Restenosis rates with DES have been improved to 5 to 10 %, compared to that with conventional stents (20-30%). We also perform procedures using rotablators, excimer lasers, DCA and so on.

Endovascular Treatment(EVT)

Many EVT cases (about 400 per year) are performed in our center. We actively treat peripheral vessel diseases such as arteriosclerosis obliterans and venous shunt occlusions in the lower extremities, renal artery stenosis. Our EVT has enabled patients with difficulty of walking to visit the hospital as an outpatient on foot. The field of such procedures is a specialty of us.

Arrhythmia Treatment

For lethal arrhythmia, we implant implantable cardioverter defibrillator (ICDs) or perform radiofrequency catheter ablations.

Heart Failure Treatment

Progress of Heart failure treatment is remarkable, and we can treat it both by drug therapy and by cardiac resynchronization therapy (CRT) with biventricular pacing.

After completing our new hospital building in December 2018, we now have two catheterization rooms dedicated for cardiovascular procedures, one multi-purpose catheterization room, and two hybrid catheterization rooms. Consequently, the number of stent graft and TAVI cases has been steadily increasing. Under these circumstances, in the same year we introduced a new biplane angiography system of Shimadzu, Trinias B12 unity edition (referred to as "Trinias" system below) and stared to use it for EVT and radiofrequency catheter ablation procedures. As the result, we cover almost all procedures that we intend to offer. The more we use the Trinias system, the more we admire its superb operability developed with the specific craftsman spirit of Japanese manufacture. In this article, I want to review how our hospital uses the revolutionary function offered by the SCORE Chase and the clinical utility it provides, particularly for EVT.

2. Trinias Features I Particularly Recommend

After nearly one year since we started using the Trinias biplane system, I am most impressed with the following features.

1. Achieves low dose levels while maintaining high image quality.
2. The field of view is square 12-inch (about 30 cm) on a side, on the other hand outward form size is compact. Therefore, we can use for both PCI and EVT procedures without stress.
3. Stent position can be confirmed easily by using a function creating stent enhancement images in real time (SCORE StentView).
4. In interventional procedures in the lower extremities, both RSM(Realtime Smoothed Mask DSA) images and DSA images can be obtained only with a single contrast media injection by computed-table motion (SCORE Chase).
5. Tilting the catheterization table up to 16 degrees to the left or right (tilt function) makes it easier to puncture below the knee(BK).
6. Fusion images combined with CT images can be created, and it can be synchronized with the C-arm angle.

Fig.1 Trinias B12 unity edition (Model with Multifunctional Catheterization Table)

3. SCORE Chase Function

SCORE Chase function is outlined below. To fully utilize the capabilities of SCORE Chase, we introduced a multifunctional catheterization table that can be tilted, rolled and panned with motor-driven. In addition, the table has computer-controlling system which enables automatic positioning and coordination linking with various applications. We fully realize that less invasive treatments, especially not only reducing the quantity of contrast media used for patients but also reducing the radiation exposure to physicians, is fulfilled by those functions.

1. Automatically and Instantaneously Displays Long-View Images Showing Overall Lower Extremities
   — SCORE RSM displays long-view images with blood vessel enhancement. It is possible to pan the table to follow the flow of contrast media because Long-view image is generated by automatic correction for any panning.
   — Long-view subtraction images of overall lower extremities can also be obtained using RemoteChase DSA.
2. Positioning is Possible without Performing Fluoroscopy
   — The virtual field of view of FPD is shown on the long-view image, which enable to confirm estimated irradiation area without fluoroscopy.
3. Long-View Images Provide a Fluoroscopy Roadmap
   — If the patient does not move after the acquisition, long-view images can be used for fluoroscopy roadmap. That can help reduce contrast media use.

In most cases of EVT, we use Remote Chase DSA to observe and grasp the blood flow of the overall lower extremities including stenotic areas. That requires working with radiological technologists, but we made it routine and increased experiences. As a result, we are now able to obtain long-view subtraction images quite easily. That procedure and corresponding movements are shown in **Figs. 2 to 6**. Images from clinical use are also shown in **Fig. 7**.

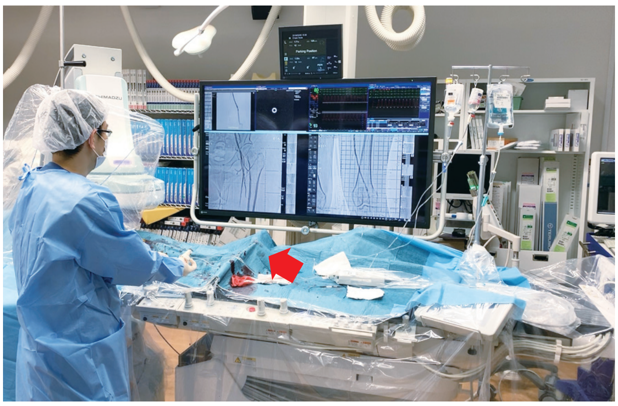

Fig.2 For most patients, overall lower extremities can be observed and acquired, without reversing head and feet positions, by setting the front C-arm at an oblique position. In the picture, the irradiation area is positioned around the common iliac area from where injected contrast media flows. The feet tips are indicated with a red arrow.

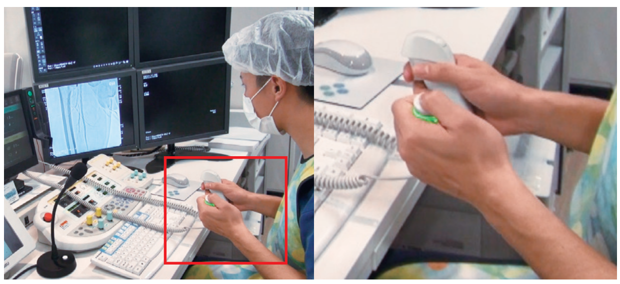

Fig.3 Start acquisition of the lower extremities when the radiological technologist gives the signal. Long-view images of the overall lower extremities are acquired by using the X-ray emission switch (left hand) and the ChaseConsole dedicated table controller (right hand) to control table movement to follow the flow of contrast media.

Fig.4 Acquire the flow of contrast media up to feet tips.

Fig.5 Perform mask acquisition sequentially. ChaseConsole, mentioned above, enables to completely reproduce the same starting position.

Fig.6 The multifunctional catheterization table automatically traces the same movements (movement speed and ending position) as the initial angiography during mask acquisition. A subtraction image is displayed in real time in the lower left area of the monitor screen during mask acquisition. A long-view image is automatically created immediately after acquisition.

By using long-view radiography, we can see stenosis condition of the overall lower extremities. In particular, long-view images can be zoomed and panned in the monitor screen keeping the original resolution, and we can display the interested region immediately without scrolling here and there with a mouse unlike the conventional system. The images also make it easy to compare vessel condition of before and after the procedure and make it extremely easy to explain it to the patient as highly understandable images.
Although we perform angiography with Iopamiron 370 diluted by about three times to minimize amounts of contrast media, we still obtain good

Fig.7 Left: Long-View RSM Image
Right: Long-View DSA Image after Mask Acquisition

images with high contrast due to the outstanding performance of the Trinias. We are confident that the burden on patients is reduced.

4. Clinical Example of Using ChaseMAP

SCORE Chase also enables automatic fluoroscopy roadmap based on long-view images. The position information in long-view image can be transferred to the catheterization table. In addition, the table can be automatically moved to the target area, and we can perform fluoroscopy roadmap at the spot. Because a mask image for roadmap does not need to be acquired again, that enables to reduce the amount of contrast media used.

Case Studies

A case of an EVT procedure on a 77-year-old woman with 90 % blockage in the proximal region of the right superficial femoral artery (SFA) **(Figs. 8 to 10)**.

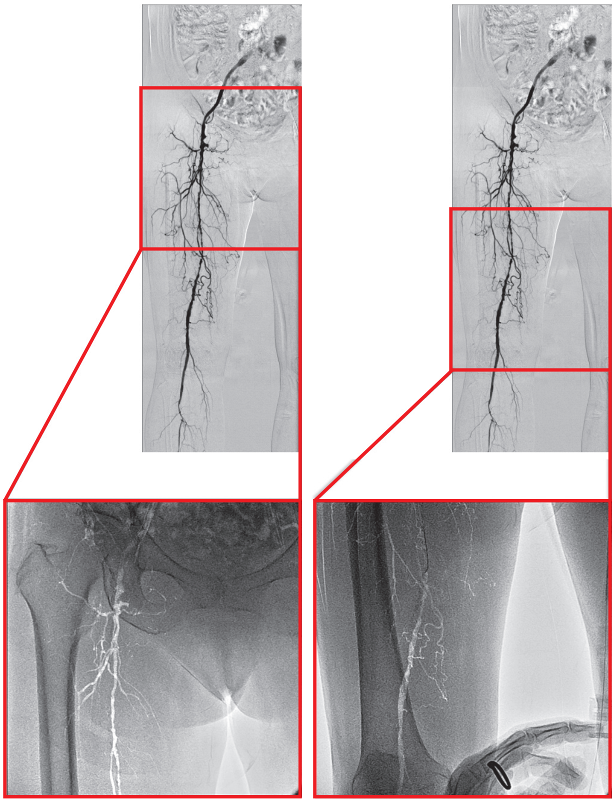

Fig.8 ChaseMAP around Two Stenotic Regions
Because the blood vessel mask is created from the long-view image, the roadmap can be created without using contrast media again. The catheterization table moves automatically to the specified blood vessel location.

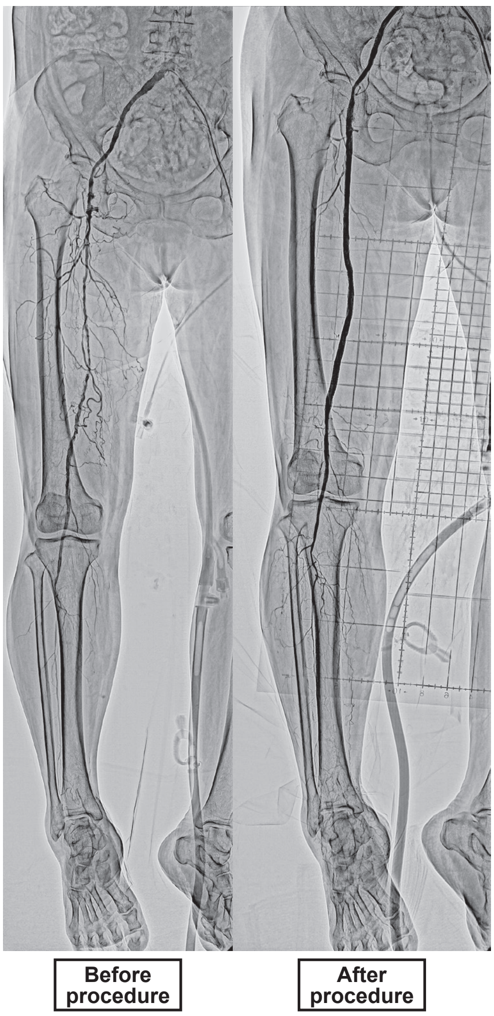

Fig.9 RSM Long-View Image Comparison before and after Procedure

Fig.10 DSA Long-View Image Comparison before and after procedure

The contrast media used for long-view acquisition was Iopamiron 370 diluted by about 3 times (3 cc contrast media plus 7 cc saline solution). The medium was injected into one foot, pushing the plunger with as much force as possible by hand.

Conclusion

Before the Trinias was introduced, I had not ever created even normal roadmaps in EVT to prioritize procedure speed. However, the Trinias functions described in this article not only shortens the procedure time, but also reduces amounts of contrast media, therefore I now actively use those functions. Furthermore, though I could not mention above, Trinias also has SCORE Navi+Plus function that can link fluoroscopy images with 3D images from CT. Using that with the other functions can help reduce the stress on patients further in EVT procedures.

Minimally Invasive Procedures in Practice
—Initiatives at the Japanese Red Cross Nagano Hospital—

Medical Systems Division, Shimadzu Corporation
Hiroyuki Kinoshita

As interventional procedures become increasingly complex and advanced, there is a demand for angiography systems that help reduce X-ray doses, reduce contrast medium usage, and shorten examination times. Shimadzu's latest Trinias series angiography systems are equipped with various functions to facilitate minimally invasive treatment.

This article describes initiatives at the Japanese Red Cross Society Nagano Hospital in lower extremity endovascular treatment and catheter ablation for arrhythmia.

1 3D Roadmap with CT Images for Occluded Vessels in Lower Extremities

Vascular roadmap functions such as DSA-MAP and FluoroMAP (MAP functions) are often used for lower extremity interventions. These functions overlay a vessel image acquired by DSA over fluoroscopy images **(Fig. 1)** and support safe and effective treatment. Because the vessel images are two-dimensional, they must be re-acquired each time the observation angle changes, which can increase contrast media in situations that require multiple observation angles such as imaging the iliac artery or other vessels with complex bends in the anteroposterior direction.

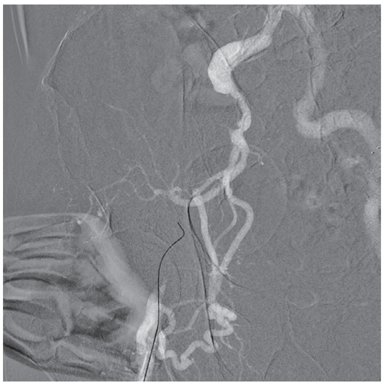

Fig. 1 DSA-MAP Function

The Japanese Red Cross Nagano Hospital uses 3D Roadmap functions*1 with lower extremity CT images when treating cases of chronic total occlusion (CTO) in the iliac region **(Fig. 2)**. CT slice data is uploaded onto a Trinias series SCORE 3D Workstation where necessary structures are extracted and the 3D Roadmap function combines 3D images with fluoroscopy images. The 3D Roadmap function provides vessel images at any C-arm angle in any table position without the need for additional imaging in DSA with contrast injection, and thereby reduces the exposure of patients to x-rays and the number of contrast injections.

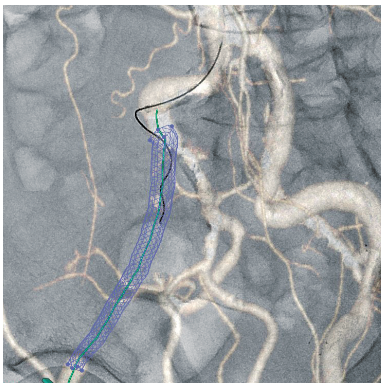

Fig. 2 3D Roadmap Function

Furthermore, if the occluded vessel is visualized on the SCORE 3D Workstation in advance, the path of the occluded vessel can be displayed in 3D Roadmap to assist with safe manipulation of guidewires and other devices. The Japanese Red Cross Nagano Hospital extracts the occluded vessel from image data by selecting just the center of the occluded vessel on multiple axial sections, creating a path along these points, then creating a virtual stent*1 along that path **(Fig. 3)**. Compared to the normal method, which traces the edges of the vessel on multiple axial images **(Fig. 4)**, this method is extremely

A Word from Youichi Itoh, R.T., Department of Diagnostic Radiology

In 2018, the Japanese Red Cross Nagano Hospital updated one of its two angiography systems to a Trinias B12 unity edition. Each year, the hospital performs approx. 600 coronary angiographies (CAGs), 250 percutaneous coronary interventions (PCIs), 250 ablations, and 50 to 80 lower extremity endovascular treatments. Although radiological technologists work on a rotation system, everyone can easily operate the system even if he/she has less experience with the system, because it has simple interface. In addition, the Trinias system produces clear and good quality fluoroscopy images, therefore eye strain is not an issue and the system received positive reviews from physicians regardless of the procedure. These features may also provide scope for further X-ray dose reductions using digital zoom or other techniques.

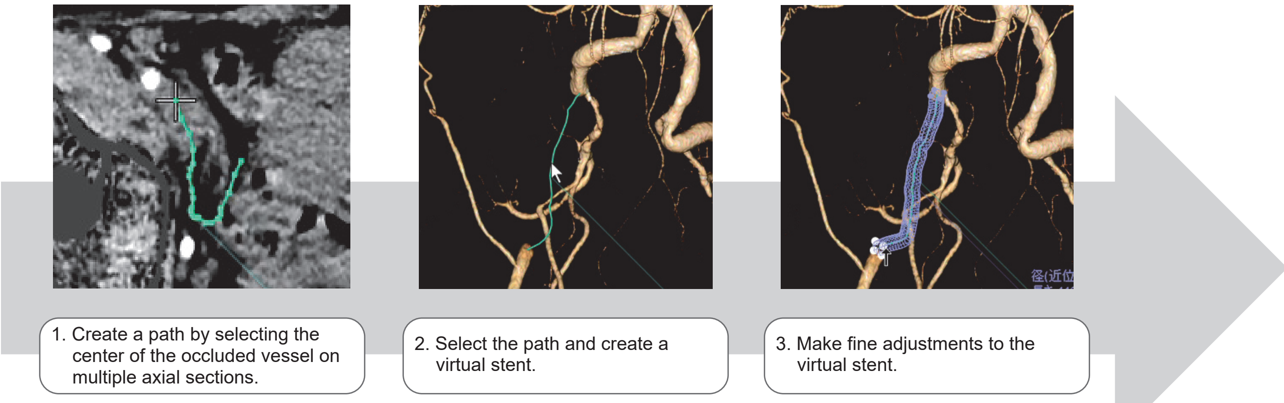

Fig. 3 Visualizing an Occluded Vessel with a Virtual Stent

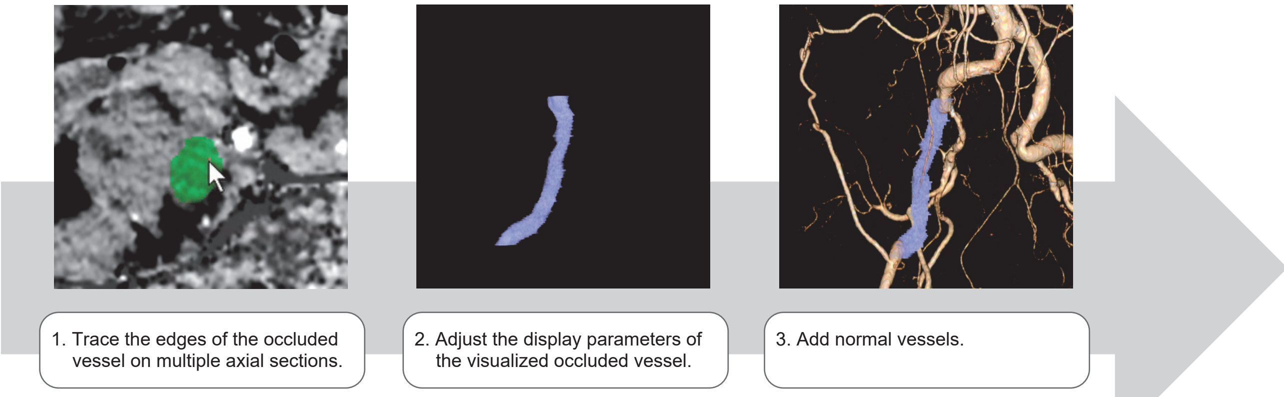

Fig. 4 Normal Visualization of an Occluded Vessel

simple and visualizes the occluded vessel relatively quickly via simple operations. Although vessel edges are not represented accurately by this method, the Japanese Red Cross Nagano Hospital notes this technique is adequate to see the route of the occluded vessel in the 3D Roadmap.

2 Using Ultra-Low Dose Mode in Ablation

Determining to what extent X-ray dose can be reduced while still completing treatment is also a topic of interest in catheter ablation for arrhythmia.

The Japanese Red Cross Nagano Hospital reduces fluoroscopy doses substantially by using the original “5 pps/ExLow-3” ultra-low dose fluoroscopy program*2. In this mode, the density parameter*4 in the 5 pps/ExLow*3 program for ablation is reduced even further from -1 to -3, and the X-ray dose is reduced by 87 % compared to the usual 10 pps/Normal program **(Fig. 5)**. With this ultra-low dose program, treatment is completed with a patient entrance reference point dose of around 200 mGy per ablation procedure (mean duration of fluoroscopy : around 65 min). In terms of image quality, users have noted the ultra-low dose program provides adequate device visibility.

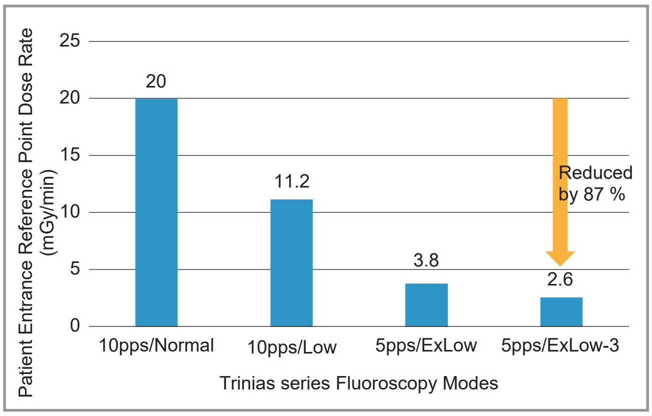

Fig. 5 Dose Rates Compared by Fluoroscopy Mode
Patient entrance reference point dose rates for FOV 8 inch, acrylic 20 cm.
• Measured values that appear in Shimadzu’s clinical application manual.
Calculated values for 5 pps.

*1 Requires SCORE Navi+Plus option.
*2 pps: pulse per second
*3 The ultra-low dose program for ablation is included from DAR-9500f version 6.8 onwards.
*4 Density is a parameter that controls the incident dose on the FPD.
Reducing density by 1, X-ray parameters are controlled to reduce the incident dose by approx. 15 %.

R/F

Our Experience Using the SCORE PRO Advance, New Low-Dose Fluoroscopic Image Processing, for Pancreaticobiliary Regions

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At the 55th Annual Meeting of the Japan Biliary Association (from October 3rd to 4th, 2019), Shimadzu conducted a luncheon seminar jointly with the association on October 3rd. With Masahiro Serikawa,Ph.D., Clinical Lecturer, Department of Gastroenterology and Metabolism, Graduate School of Biomedical & Health Sciences, Hiroshima University invited to chair the seminar, a presentation entitled "Our Experience Using the SCORE PRO Advance, New Low-Dose Fluoroscopic Image Processing, for Pancreaticobiliary Regions" was given by Yoshitaka Nakai, M.D., Deputy Director, Department of Gastroenterology, Digestive Disease Center, Kyoto Katsura Hospital. This article provides a summary of that presentation.

1. Introduction

Given the importance of interventional radiology (IVR) examinations such as endoscopic retrograde cholangiopancreatography (ERCP), endoscopic ultrasonography (EUS), or percutaneous transhepatic procedures to diagnose and treat patients with biliary tract or pancreatic disorders, X-ray R/F systems have become essential equipment for those examinations. However, to ensure the accuracy and safety of such examinations, the systems must provide high image quality and easy operability. Of course, because fluoroscopy systems emit radiation, users must be constantly mindful of radiation dose levels. On the other hand, survey results of medical staffs by Okuyama, et al. indicated that "Many medical staffs are inadequately aware of radiation exposure."[1)]
Therefore, in an effort to increase interest in X-ray fluoroscopy examinations and proceed responsible diagnostic and treatment practices that minimize radiation dose levels to patients, I would like to report our experience with using the SCORE PRO Advance, new low-dose fluoroscopic image processing, based on basic knowledge about X-ray fluoroscopy examinations and our actual operations at our Digestive Disease Center.

2. Fundamentals of X-Ray Fluoroscopy Examinations

Some possible reasons for the low interest in X-rays even among many medical staffs could be that X-rays are not visible, their interest is focused on endoscopy or other procedures, and that harm from X-rays is not immediate.
Therefore, to gauge the physician interest level at our center, we asked each physician the following question. "How is the character for 'Hibaku' (X-ray radiation exposure) written (in Japanese)?" The correct answer is "被ばく". However, many answered "被爆" or "被曝". "被爆" means being bombed specifically by an atomic or hydrogen bomb. In contrast, "曝" of "被曝" is not among standard characters recommended for common use by the Japanese government. Therefore, it is officially written as "被ばく" using the phonetic symbols of "ばく" (baku) in regulatory guidelines, newspapers, and academic papers related to X-ray radiation. Occasionally, I notice it written "被曝" in papers about the digestive system, however. I hope learning this basic fact will serve as a first step toward having an interest in radiation exposure.
X-ray R/F systems essentially are an X-ray detecting system that can rapidly collect X-ray and output the images. By rapidly acquiring a series of X-ray images and connecting them together, the images can be made to appear as a video, which is analogous to flip-book animation. By acquiring about 30 images per second, the eyes are able to recognize the sequence of still images as a moving image. However, such fluoroscopic images are acquired using far lower radiation dose levels than that for normal radiography images, so the resulting fluoroscopic images appear grainy. Generally speaking, fluoroscopic image quality

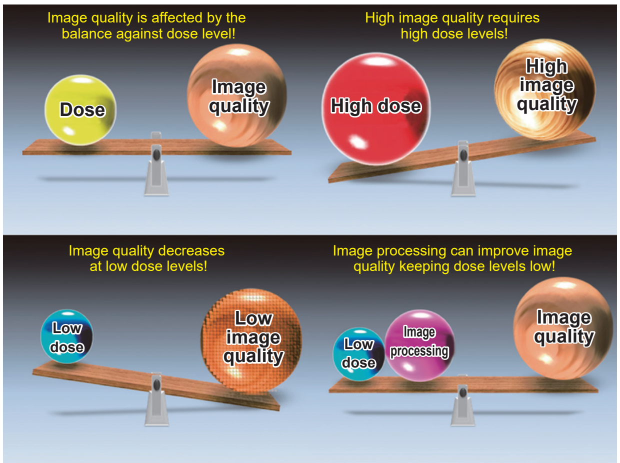


Fig.1 Balance between Fluoroscopic Image Quality and Dose Level

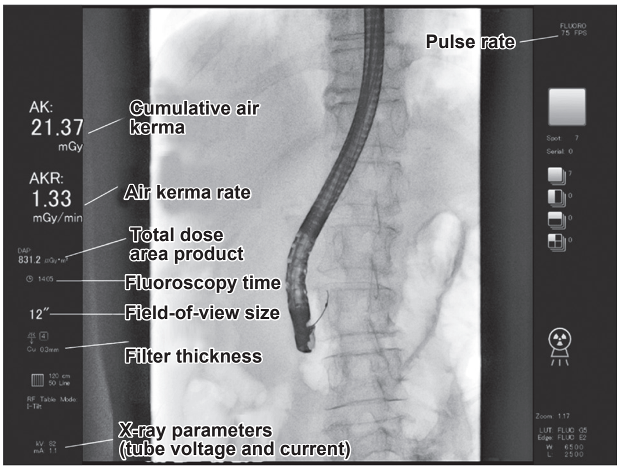


Fig.2 Fluoroscopy Parameters Displayed on the Fluoroscopy Monitor

improves as dose level is increased and image quality deteriorates as the dose is decreased **(Fig. 1)**. Advantages of higher image quality include improved visibility, less eye strain, and shorter examination times for the healthcare personnel and safer, more reliable, and more accurate examinations for patients. On the other hand, achieving higher image quality requires applying higher X-ray dose levels, which can cause radiation problems by the e direct or scattered X-rays.

Recently, Itoi, Kiso, et al. reported that "scattered radiation protective cloth for fluoroscopy systems is effective in reducing exposure to scattered radiation (about 80 to 90 % reduction of scattered X-rays).".[2),3)] Consequently, many facilities, including our center, have started using such protective cloth. Results from verifying the effectiveness of the protective cloth to reduce scattered radiation exposure levels at our center indicated an 87.1 % reduction in exposure to the physician. However, considering that we know about the probabilistic effect where the higher the radiation dose level, the higher the risk of cancers, leukemia or other genetic effects, that reports indicate bodily effects cannot be ruled out even at low dose levels below 100 mSv[4)-6)], and that the protective cloth cannot be used in some situations, we must continue to strive to minimize exposure levels.

The X-ray dose rate at the patients undergoing interventional procedures for the pancreaticobiliary system is roughly 10 to 20 mGy/min. The guideline for radiation dose used for cardiovascular interventions specifies a maximum 2 Gy as the threshold value for deciding to stop the procedure.[7)] The 2006 Japanese Guideline for Medical Radiation Exposure specifies less than 25 mGy/min as a target value for reducing dose levels in radiological examinations and treatments.[8)] If an examination lasts a long time, the cumulative dose must be monitored at all times during the examination.

Recent fluoroscopy systems display various information on the fluoroscopy monitor screen **(Fig. 2)**, which means physicians and other medical staffs need to perform examinations responsibly with paying attention to not only the fluoroscopic images, but also those numerical values displayed.

3. X-Ray Fluoroscopy Examinations at the Digestive Disease Center

Our Digestive Disease Center treats pancreaticobiliary disorder cases mainly under the direction of three advising physicians and performs about 400 fluoroscopy examinations per year.

The use of X-ray fluoroscopy examinations can vary depending on the facility size, number of medical staffs, and what is involved in the examinations.

There are two basic system styles available for X-ray R/F systems in Japan: Over-tube table models and C-arm types. The over-tube models are configured with the tube positioned over the table and the detector installed under the table-top. Whereas C-arm models can position the tube under or over the table, whichever. The advantages and disadvantages of each configuration are summarized in **Table 1**. Selection between those two configurations depends on whether the system will be used exclusively for pancreaticobiliary procedures or also for gastrointestinal and other examinations/procedures. Because our center uses the system not only for pancreaticobiliary procedures, but also for gastrointestinal procedures, we selected a system with an over-tube configuration, due to its advantages of broad applicability, large table area, large space

Table 1 Advantages/Disadvantages of Over-tube vs C-Arm Models

Comparison between Over-tube models and C-Arm Models

	Over-tube table	C-Arm table
Broad Applicability	High	Low
Installation Space	Small	Large
Image Quality	Stable	Good
Observable Range	Narrow	Wide
Working Space	Large	Small
Scattered X-Ray Radiation	High	Low
Price	Reasonable	Expensive

between the table and tube that makes it easier to perform procedures, the space-saving size, and the sturdy and stable system structure.

We think using protective cloth to block scattered radiation can sufficiently mitigate the over-tube system's disadvantage of higher radiation dose to physicians, compared to under-tube models.

As for our staff operation including even for emergencies, we always work as a team of at least four professionals, consisting of a physician, assistant, nurse, and radiological technologist, to ensure examinations are performed safely and reliably. Sometimes, physicians can become so focused on operating the endoscope or watching the fluoroscopic image that they accidentally continue emitting fluoroscopic radiation. That can occur more, if the examination time becomes longer in the difficult procedure cases, or if the physician is not much experienced. To minimize such risks, our center assigns a dedicated radiological technologist to regular examinations. That technologist can adjust or switch the types of radiography modes indicated in **Table 2** with his experience to understand the intentions of the physician, and provide optimal image quality and X-ray dose levels. Furthermore, the technologist helps reduce exposure dose levels by switching fluoroscopy ON or OFF by his decision. In addition, he also contributes to early discovery of any adverse events by observing the overall examination from outside the examination room and pointing out any guidewire or device problems overlooked by the physician or assistant.

Our approach at the Digestive Disease Center is to assign a dedicated radiological technologist and share responsibilities, so that we can perform examinations safely, smoothly, and less stressfully, while also making every effort to minimize unnecessary radiation exposure.

Table 2 Adjustable functions that can affect Fluoroscopic Image Quality

Switching and Adjusting Radiography Modes

- ✓ High image quality (high dose mode) ↔ Low image quality (low-dose mode)
- ✓ Adjust pulse rate of pulsed fluoroscopy (15 ↔ 3.75 fps)
- ✓ Enlarge ⇔ reduce field-of-view size (17 ↔ 6 inches)
- ✓ Adjust the irradiation field using the collimator
- ✓ Adjust contrast or brightness
- ✓ Move image to region of interest
- ✓ Adjust observed area by oblique projection of X-ray

It is excellent at our Center to assign a dedicated radiological technologist and share responsibilities, so that we can perform examinations safely, smoothly, and less stressfully, while also making every effort to minimize unnecessary radiation exposure.

4. Our Experience Using SCORE PRO Advance

The Digestive Disease Center introduced a Shimadzu SONIALVISION G4 fluoroscopy system in October 2016 for endoscopic diagnosis and treatment. In September 2018, we started using the SONIALVISION G4 in combination with its Super Low Dose mode in the SUREengine FAST (digital image processing software which can reduces X-ray dose levels without decreasing pulse rate) for pancreaticobiliary endoscopy. Then recently, in July 2019, we introduced SCORE PRO Advance on a trial basis, which we evaluated at our center using phantoms **(Fig. 3)** and actual clinical use. That experience is described below.

SCORE PRO Advance is intended for maintaining image quality even at low dose levels, by (1) graininess improvement, (2) image lag reduction, and (3) improvement of device visibility through edge enhancement. Three modes are available for fluoroscopy —the high image quality mode (ERCP2), standard mode (ERCP (LD: Low dose) 2), and low-dose mode (ERCP (LD) 3) **(Table 3-a)**. In addition, the pulse rate can be changed to 15, 7.5, or 3.75 fps for pulsed fluoroscopy. **Fig. 4** shows the image quality obtained with each mode at 7.5 fps. Assuming the dose at 15 fps in the high image quality mode as

Fig.3 Evaluation of SCORE PRO Advance using a Phantom at our Digestive Disease Center

Table 3 a) SCORE PRO Advance Fluoroscopy Mode Settings

Procedure	Fluoroscopy Mode (Fluoroscopy dose)	Cu Filter Added (mm thick Cu)	Pulse Rate (Default Setting)
ERCP2 (High Quality Mode)	Pulse N	0.1	7.5fps
ERCP (LD) 2 (Standard Mode)	Pulse L2	0.3	7.5fps
ERCP (LD) 3 (Low-Dose Mode)	Pulse L3A	0.3	7.5fps

Table 3 b) Dose Reduction Ratio for Each SCORE PRO Advance Fluoroscopy Mode and Frame Rate Setting (1)

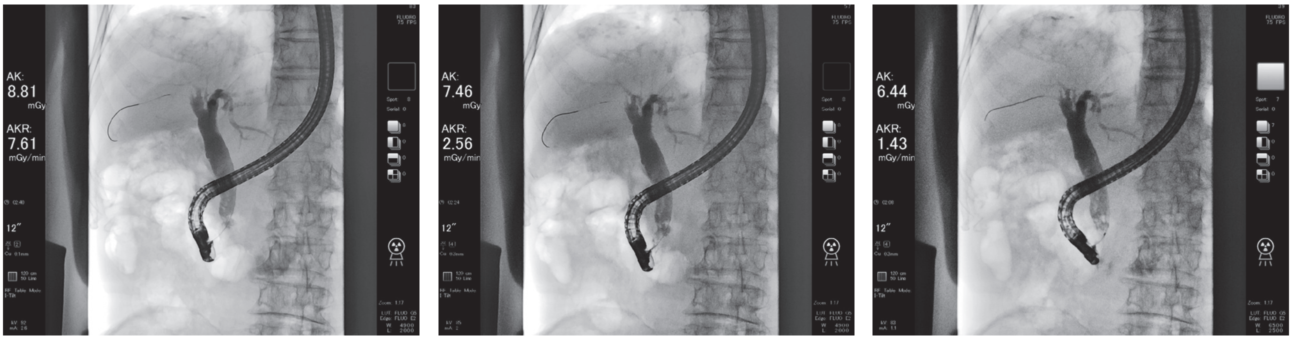
Procedure	15 fps	7.5 fps	3.75 fps
ERCP2 (High Quality Mode)	100%	50%	25%
ERCP (LD) 2 (Standard Mode)	40%	20%	10%
ERCP (LD) 3 (Low-Dose Mode)	23%	11.5%	5.75%

Table 3 c) Dose Reduction for Each SCORE PRO Advance Fluoroscopy Mode and Frame Rate Setting (2)

Procedure	15 fps	7.5 fps	3.75 fps
ERCP2 (High Quality Mode)	100%	50%	25%
ERCP (LD) 2 (Standard Mode)	40%	20%	10%
ERCP (LD) 3 (Low-Dose Mode)	23%	11.5%	5.75%

100%, the dose level can be reduced to 40 % or 20 % at 15 or 7.5 fps in the standard mode **(Table 3-b)**, or to 23 % or 11.5 % at 15 or 7.5 fps in the low-dose mode **(Table 3-c)**.

As a result of performing pancreaticobiliary examinations using SCORE PRO Advance and changing the mode appropriately for various cases, we discovered that the resolution level required for images differs depending on the type of each procedure **(Table 4)**. Using minimum image quality at 7.5 or 3.75 fps in the low-dose mode has minimal impact on procedures such as endoscope insertion or cannulation and 7.5 fps in the low-dose or standard mode provides adequate image quality even for placing plastic stents in biliary ducts or stents in pancreatic ducts. When selectively inserting a guidewire, removing a stone, or placing a metal stent in a biliary or pancreatic duct, it can be difficult to achieve adequate contrast between the biliary or pancreatic duct and the devices on the images. Such cases normally required high image quality, but we found the 7.5 fps setting in the high image quality mode was adequate for most cases. We also found that we could perform examinations more efficiently by first acquiring a radiography image and then referencing that on a second screen positioned next to the first(acquisition) screen. In cases that require more detailed image evaluation of lesion part, overall it is important to perform contrast fluoroscopy at low dose levels and then evaluate by radiography images acquired as appropriate rather than to perform contrast fluoroscopy at high dose levels for a long time.



ERCP2: High Quality Mode **ERCP (LD) 2: Standard Mode** **ERCP (LD) 3: Low-Dose Mode**

Fig.4 Comparison of Image Quality for Each Mode (Case of Choledocholithiasis)

Table 4 Resolution Required for Fluoroscopic Images in Various Procedures

Required resolution level differs for each procedure.

High

- Metal stent placement
- Stone removal
- Guidewire operations
- Plastic stent placement
- Contrast fluoroscopy
- Cannulation of biliary or pancreatic duct
- Scope insertion

Low

In addition, patient factors that can affect image quality include body thickness, quantity and position of intestinal gases, and respiration depth and count. The thicker the body or the more intestinal gases overlap with the region of interest, the less sharp images will be. Similarly, the greater the depth and number of breaths, the more image lag that will occur, which can cause inadequate recognition in the region of interest or of devices. Such cases require either switching to a high image quality mode or increasing the frame rate.

5. Summary

SCORE PRO Advance maintained adequate image quality necessary for normal pancreaticobiliary endoscopy procedures even at low radiation dose levels. It is especially recommended for facilities that intend to ensure pancreaticobiliary procedures are performed safely, reliably, and responsibly.

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R/F

Utility of Tomosynthesis for Diagnosis of Wrist Joint Disorders
—Focus on Triangular Fibrocartilage Complex Injury—

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1. Introduction

The triangular fibrocartilage complex (TFCC) is a complex of ligaments and fibrous cartilage on the ulnar side of the wrist and is a soft tissue that cannot be separated histologically.[1)] More specifically, it consists of the radioulnar ligament, ulnolunate ligament, ulnotriquetral ligament, ulnar collateral ligament, triangular fibrocartilage, and meniscus homologues. The fibrocartilage functions as articular disc to buffer loads from ulnar carpal bones and to transmit stresses to ulna. The ligaments serve to stabilize the distal radioulnar joint and the ulnar carpal row during pronation and supination of the forearm. TFCC tears are a major cause of ulnar-sided wrist pain, but due to the complicated morphology and functionality, it is often difficult to assess the location and severity of tears in images. Therefore, the localized assessments which are ulnar fovea sign, ulnar compression, or other tests and various imaging examinations are performed to assess the condition prior to surgery, and a final diagnosis depends on invasive arthroscopy of the wrist. Arthrography have utility as a supplemental examination, but because it provides projected images of the overall wrist that is in principle difficult to use for identifying the detailed location of tears. In contrast, tomosynthesis is a technology that offers high quality digital multi-slice tomographic images at low dose levels that can be used for tomography even after arthrography. Therefore, it may be possible to use tomosynthesis for detailed assessment of TFCC tears before surgery.

2. Purpose

The purpose is to verify the utility of tomosynthesis by comparing the sensitivity, specificity, and diagnostic accuracy calculated from tomosynthesis image (Tomosynthesis) and 3.0 Tesla MR image (3T-MRI) after arthrography of TFCC tears.

3. Subjects and Methods

Subjects were 42 patients that underwent surgery for TFCC tears in our department from January 2012 to September 2017. The average patient age at the time of surgery was 35.6 years and the average waiting period to the surgery from when the patient first became aware of ulnar wrist pain was 5.9 months. A 1:1 mixture of meglumine sodium amidotrizoate injection and lidocaine was used as the arthrographic contrast medium. Using fluoroscopy, the contrast medium was first injected into the radiocarpal joint (RCJ). If it did not leak out to the distal radioulnar joint (DRUJ), then contrast medium was injected into the DRUJ, according to the double-injection method. For tomosynthesis, we used T-smart (Tomosynthesis-Shimadzu Metal Artifact Reduction Technology) from Shimadzu Corporation with imaging parameters of 40 degrees tube angle, 9-inch field-of-view, and 0.5 mm slice pitch. Frontal images of the wrist were obtained with the forearm slightly pronated on the table. 3T-MRI coronal section images of the wrist were obtained with the same arm position as Tomosynthesis.

For Tomosynthesis, TFCC tears was defined as a disc proper tear if contrast medium leaked from the RCJ via the disc and into the DRUJ, a foveal tear if contrast medium leaked to the ulnar fovea, a lunotriquetral ligament (LT) tear if contrast medium appeared continuously from the ulnocarpal joint (UCJ) to the midcarpal joint, and an peripheral ulnar side TFCC tear if it was found contrast medium infiltrated into the peripheral area of the TFCC on the ulnar side and it leaked into the ulnar side beyond meniscus homologue from the prestyloid recess **(Fig. 1)**.

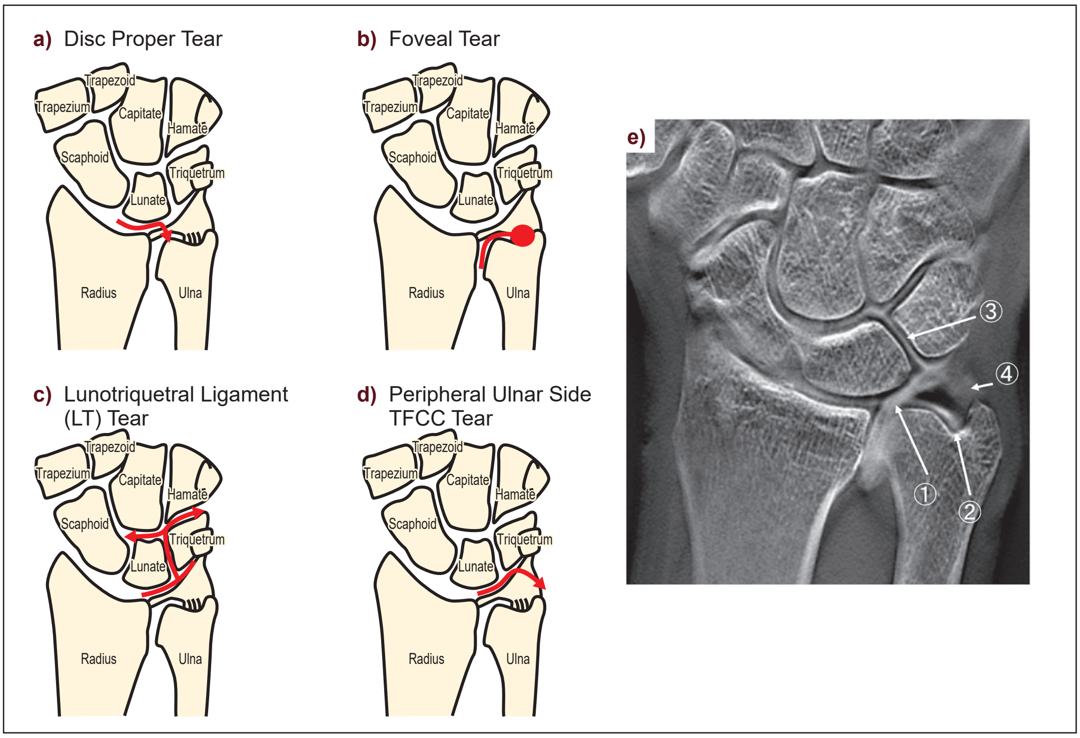

Fig.1

For 3T-MRI, TFCC tears was defined as a disc proper tear if a continuous brightness variation from the ulnocarpal to DRUJ was observed in the disc proper, a foveal tear if a brightness change was observed in the foveal attachment area no the triangular ligament, an LT tear if there was a discontinuity in ligament between the lunate and triquetrum, and an peripheral ulnar side TFCC tear if there was a discontinuity between the meniscus homologue and ulnar collateral ligament area.

The sensitivity of Tomosynthesis and MRI to the TFCC tears recognized by arthroscopy and the sensitivity, specificity, positive predictive value, and negative predictive value of Tomosynthesis and 3T-MRI to each tear were calculated. And then statistically analyzed assuming a significant difference of $p < 0.05$ based on the McNemar test.

4. Results

The sensitivity of Tomosynthesis and 3T-MRI with respect to overall TFCC tears was 97.6 % and 90.4 %, respectively (p = 0.25). The results for each tear are: For foveal tears, although no significant difference in specificity and sensitivity, the sensitivity and negative predictive value of Tomosynthesis were both 100 %, which was higher than the 84.4 % and 85 % respectively for 3T-MRI. For LT tears, Tomosynthesis provided 97.4 % specificity, which was significantly higher than the 56.7 % for 3T-MRI (p = 0.00008) **(Table 1)**.

Table 1

Comparison of Tomosynthesis vs 3T-MRI for Overall TFCC Tears

	Tomo	3T-MRI	McNemar test
Sensitivity	97.6 %	90.4 %	p = 0.25
Specificity	—	—	
Positive Predictive Value	— (100 %)	— (100 %)	
Negative Predictive Value	—	—	

Comparison of Tomosynthesis vs 3T-MRI for Disc Proper Tears

	Tomo	3T-MRI	McNemar test
Sensitivity	82.4 %	78.7 %	p = 0.48
Specificity	100 %	77.7 %	p > 0.5
Positive Predictive Value	100 %	92.9 %	
Negative Predictive Value	60 %	50 %	

Comparison of Tomosynthesis vs 3T-MRI for Foveal Tears

	Tomo	3T-MRI	McNemar test
Sensitivity	100 %	84.4 %	p = 0.25
Specificity	87.5 %	73.9 %	p = 0.13
Positive Predictive Value	86.4 %	72.7 %	
Negative Predictive Value	100 %	85 %	

Comparison of Tomosynthesis vs 3T-MRI for LT Tears

	Tomo	3T-MRI	McNemar test
Sensitivity	100 %	50 %	p = 0.25
Specificity	97.4 %	56.7 %	p = 0.0008
Positive Predictive Value	85.7 %	16.7%	
Negative Predictive Value	100 %	87.5 %	

Comparison of Tomosynthesis vs 3T-MRI for Ulnar Peripheral Tears

	Tomo	3T-MRI	McNemar test
Sensitivity	88.9 %	88.9 %	p = Not a Number
Specificity	54.5 %	45.4 %	p = 0.13
Positive Predictive Value	34.8 %	30.7 %	
Negative Predictive Value	94.7 %	93.8 %	

5. Examples of Typical Cases

A 25-year-old male noticed pain from the ulnar side of his right wrist during carpentry work, which was diagnosed by a local physician one week later and treated conservatively with orally administered

NSAIDs and topical ointment. Because the pain did not improve, he was referred to our department, where we examined him one month later. The MRI and arthrography examination revealed a disc proper tear and peripheral ulnar side TFCC tear, but none of the images showed an LT tear or foveal tear. With Tomosynthesis, we were able to diagnose not only the disc proper tear and peripheral ulnar side TFCC tear, but also an LT tear and foveal tear. All findings by Tomosynthesis were consistent with that of arthroscopy**(Fig. 2)**.

6. Consideration

MR and arthrographic images have been considered effective y for the diagnostic imaging of TFCC tears. After having the 3.0 Tesla MRI in clinical practices, the diagnoses accuracy has been improved, with sensitivity and specificity increasing to 86 % and 100 %, respectively.[2] Even in this research, 3T-MRI sensitivity for detecting TFCC tears was over 90 %, which is comparable to the high values previously reported. Meanwhile, arthrography has been performed since about 1960 before MRI was available, and has been reported to achieve TFCC tears sensitivity of 85 %.[3] In this research as well, arthrographic images without tomosynthesis resulted in sensitivity of 87.7 %, which is comparable to values reported in the past. As an alternative to MRI and arthrography, Moritomo, et al. reported that the radial imaging of mainly ulnar fovea using an arthrographic CT achieved excellent sensitivity and specificity [4], but radiation dose levels remained a problem. To achieve diagnostic imaging that is less invasive and more convenient, a new imaging technology needs to be introduced. Tomosynthesis is a low dose diagnosis method, requiring one-tenth or less radiation dose than CT, and can be performed in the same room and in the same body position as arthrography. The average exposure time is five seconds, which is quite short and helps reduce the stress on patients. The spatial resolution of tomosynthesis is considered comparable to that of radiography, about

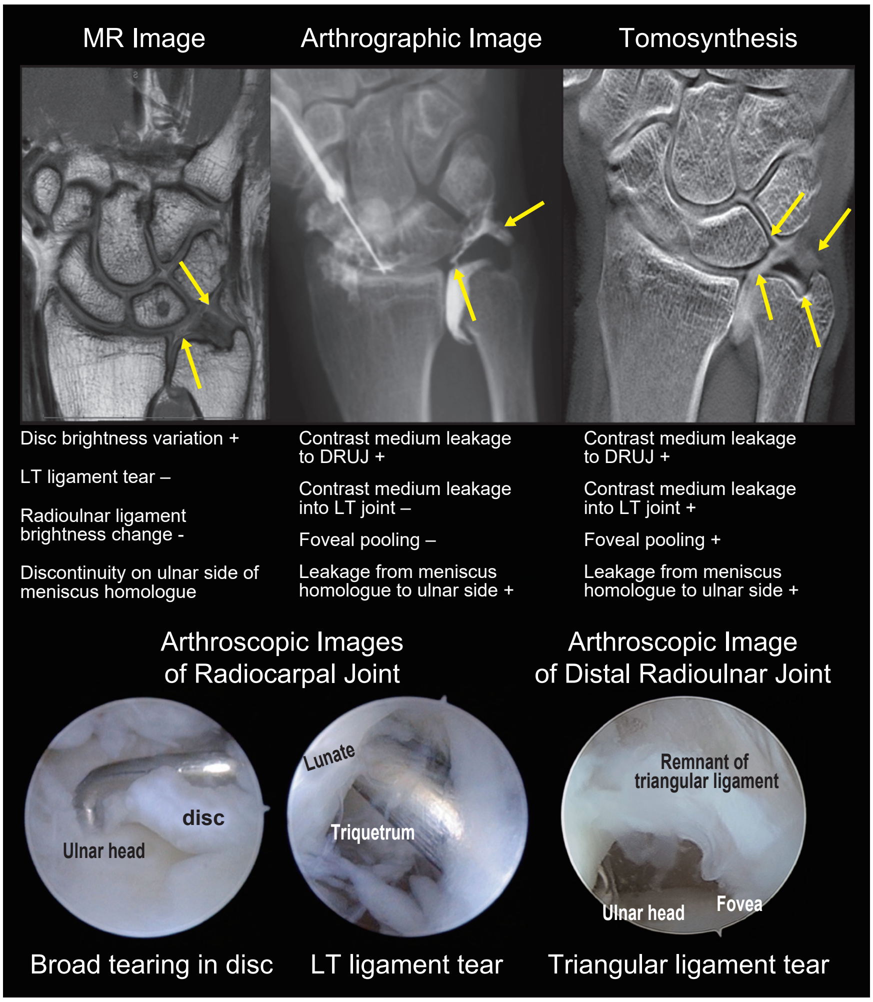

Fig.2

4 megapixels, theoretically 16 times more than the 250,000 pixels of CT. Consequently, tomosynthesis has a possibility to visualize small features of a lesion in finer detail. Furthermore, tomosynthesis generates less artifacts, so the images can be analyzed even after contrast medium is used. Therefore, we verify this study with tomographic images obtained by the tomosynthesis after performing arthrography.

Although there was no significant difference between the sensitivity of Tomosynthesis and 3T-MRI to TFCC tears, the sensitivity of Tomosynthesis was a high 97.6 %. Tomosynthesis achieved 100 % specificity and positive predictive value for disc proper tears and 100 % sensitivity and negative predictive value for foveal tears and LT tears. Given that 3T-MRI fell short of 100 % for all of those measures, I thought the high diagnostic capability of Tomosynthesis could enable identification of tears that were difficult to diagnose by MRI.

Because the distal radioulnar ligament helps stabilize the DRUJ, particularly foveal tears can result in DRUJ instability problems. In such cases, diagnostic imaging is important for planning ligament suturing or reconstructive surgery. Though there was no statistically significant difference between Tomosynthesis and 3T-MRI in our study (p = 0.25 for sensitivity and p = 0.13 for specificity), the sensitivity and negative predictive value of Tomosynthesis were 100 %. It indicates that Tomosynthesis is presumably effective for preoperative diagnostic imaging. For LT tears, Tomosynthesis had 98 % diagnostic accuracy, which was significantly higher than the 57 % for 3T-MRI. The LT is an important part for diagnosing TFCC tears complicated with ulnocarpal abutment syndrome and LT tear can cause persistent pain after ulnar shortening osteotomy.[5] If LT tear is assessed before surgery, then the possibility of residual the pain due to LT tear can be considered in the treatment plan, which presumably means Tomosynthesis has utility for LT evaluation as well.

Though the difference is not significant, the lowest diagnostic accuracy in peripheral ulnar side TFCC tears was 62 % of Tomosynthesis, whereas theaccuracy of 3T-MRI was 83 %. The positive predictive value might have become lower as a result of diagnosing following cases as tear: small slit tears formed on the normal meniscus homologue, prestyloid recess, or ECU subsheath that form the ulnar periphery (which was minimal enough that it did not require repairing) and contrast medium leakage into the ulnar side during other wrist movements after the contrast medium was injected. Therefore, for diagnostic imaging of TFCC tears, it is presumably important to judge comprehensively considering location of each tear and characteristics of each examination method. Arthrography can have 20 ~ 35 % false negatives due to lack of contrast medium leakage from the RCJ to the DRUJ for disc wear alone or lack of contrast medium leakage for flap blockage in small flap tears.[6] Given that there are 17.6 % false negatives for disc proper tears in this study as well, we thought it can be worth changing the contrast medium injection pressure or modifying other wrist movements after contrast medium injection until images are acquired.

Summary

1. The accuracy of Tomosynthesis and 3T-MRI for diagnosing TFCC tears before surgery was compared.
2. The diagnostic accuracy for foveal tears was 95 % for Tomosynthesis and 79 % for 3T-MRI. For LT tear the diagnostic accuracy for Tomosynthesis was significantly higher than 3T-MRI, with 98 % for Tomosynthesis and 57 % for 3T-MRI.
3. Tomosynthesis is considered to offer significant utility for diagnostic imaging of TFCC tears before surgery.

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R/F

Development of the SONIALVISION G4 LX edition

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1. Introduction

SONIALVISION G4 R/F systems feature a large FPD and provide exceptional image quality and easy operability for tomosynthesis, and an extensive assortment of other applications. Consequently, customers have especially praised their ability to be used for such a broad range of clinical applications.

Shimadzu has now developed the SONIALVISION G4 LX edition that includes a wide variety of new functionality (referred to as "G4 LX edition" below and shown in **Fig. 1**), an even more advanced version of the SONIALVISION G4 ("G4" below). This article describes the following new functionality.

- SCORE PRO Advance enables fluoroscopy with even lower radiation dose and higher image quality levels.
- An R/F table with 1.8 m SID and a wireless FPD expands the applicability of radiography.

Note that some of the new functionality can be optionally added to existing G4 systems.

Fig.1 SONIALVISION G4 LX edition

2. SCORE PRO Advance

Using SUREengine FAST image processing engine to control fluoroscopy parameters, the G4 provided excellent image quality and low radiation levels for endoscopic examinations, which have become increasingly popular in recent years.[1), 2)] To achieve even higher fluoroscopic image quality, while also achieving low radiation dose levels, and expand applicability to gastrointestinal X-ray examinations, the G4 LX edition features a new SCORE PRO Advance fluoroscopic image processing engine that significantly increases processing capacity.

2.1 SCORE PRO Advance Features

In addition to the multi-frequency processing and recursive filter processing functionality included previously, SCORE PRO Advance also offers motion tracking noise reduction and object extraction-based edge enhancement that selectively enhances edges based on their structure **(Fig. 2)**. That achieves higher noise reduction and improved visibility of detailed structures than previous image processing, while also minimizing image lag effects during inter-frame processing. Such complex image calculation processes are performed on Shimadzu's unique high-speed image processing board that prevents delays in displaying images, which can interfere with examination procedures.

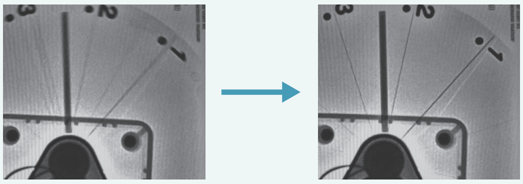
2.2 Benefits of SCORE PRO Advance

An example of using SCORE PRO Advance for a gastric X-ray examination is shown in **Fig. 3**. It shows that SCORE PRO Advance results in less blurring due to image lag than previous image processing and clearly indicates the stomach edges and direction of gastric rugae.

As a result of such image quality improvements, SCORE PRO Advance can provide equivalent image quality using only about 40 % of previous X-ray dose levels, which means it can reduce

■ Adoption of the latest motion tracking noise reduction

By performing block matching between frames, and recursive processing between the most matched blocks, noise is efficiently reduced without any lag.



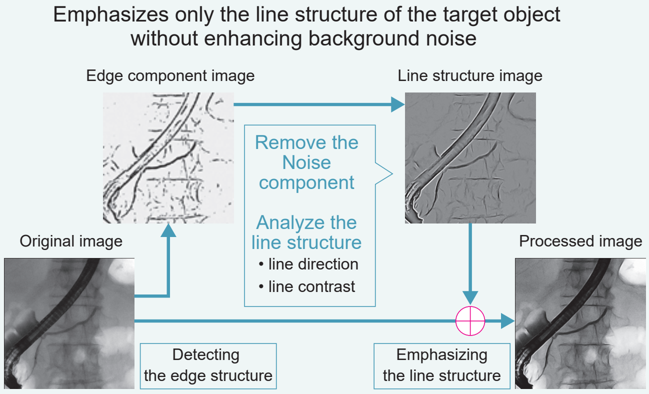


Fig.2 SCORE PRO Advance Motion-Tracking Noise Reduction (left) and Object Extraction-Based Edge Enhancement (right)

(a) Previous Processing **(b)** SCORE PRO Advance

Fig.3 Applicability of SCORE PRO Advance for Gastric X-Ray Examination

radiation exposure levels by 60 % from previous levels. Also, due to significantly lower image lag, visibility decreases can be minimized even at low pulse rates. That means exposure rates can be reduced even further by decreasing the pulse rate setting (example: 15 → 7.5 → 3.75 fps) based on the amount of movement of the target object being observed.

4. R/F Table with 1.8 m SID (Optional)

The SID (source-to-image distance) setting on the G4 can be switched to 1.1, 1.2, or 1.5 m, whereas the G4 LX edition was developed with a redesigned telescoping column mechanism on R/F table, so that the SID can be switched to 1.1, 1.5, or 1.8 m. The ability to select the 1.8 m SID setting on the R/F table allows chest and abdominal radiography to be performed easily in the standing position **(Fig. 4)** without using a ceiling-mounted X-ray tube support (for a second X-ray tube) and a Bucky stand.

5. Wireless FPD (Optional)

The G4 LX edition can be used in combination with a 14 × 17-inch wireless FPD for radiography **(Fig. 5)**. Previously, adding an FPD unit for radiography required installing a separate image processing console for the radiography FPD, but the G4 LX edition is able to perform all display and control functions via the image processing console on the main unit. That leaves more space in the control room and dramatically improves operability, with examination information and images for both the fluoroscopy FPD and the radiography FPD units managed from a single location. The system can switch smoothly between either FPD unit during examinations, which is even helpful for myelography and other examinations that involve using a ceiling-mounted X-ray tube support system to acquire radiography images from the side during fluoroscopic examinations.

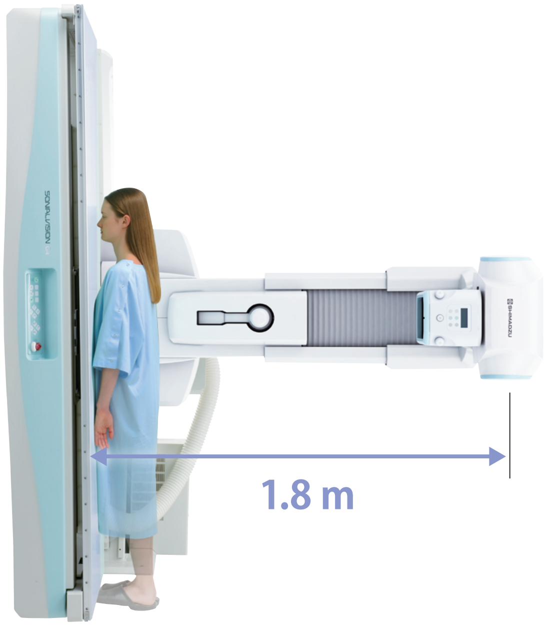


Fig.4 Chest Radiography with a 1.8 m SID

(a) Radiography with FPD Placed on the Table

(b) Lateral Radiography

Fig.5 Radiography Using Wireless FPD
(In combination with a ceiling-mounted X-ray tube support)

6. Conclusion

This article describes the new SONIALVISION G4 LX edition R/F system, which offers lower radiation levels, higher image quality, higher labor efficacy, and better examination room space efficacy. Based on feedback from customers, we will continue to offer new advancements for providing better healthcare in the future as well.

Lastly, we wish to thank everyone at the Nippon Koukan Hospital for providing clinical images and all the doctors and many others that offered such generous help and advice during the development of the system.

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RAD

Our Experience Using the RADspeed Pro for Dynamic Chest Radiography

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Ryotaro Yuji

1. About our Hospital

Tokai University Hachioji Hospital is a general hospital in Hachioji City, established in 2002 in response to an invitation from the Hachioji City to provide healthcare services to the residents in Hachioji City and the South Tama region. It is also designated by Hachioji City as one of the central hospitals of Hachioji (Fig. 1). Currently, with 30 departments and 500 beds, it offers 24-hour secondary emergency care and is designated by Tokyo Metropolitan Government as a disaster base hospital and also as a hospital for treating cancer. In general, it is a mid-size hospital with a limited number of radiography rooms, but recently the equipment that enables dynamic radiography as well as general radiography was installed. This article introduces our experience using it.

Fig.1 Tokai University Hachioji Hospital

2. Appearance and Characteristics of the System with Dynamic Radiography Capability

The newly introduced system that supports dynamic radiography looks just like a common radiographic system, but it consists of a General Radiographic System - RADspeed Pro by Shimadzu Corporation that enables serial radiography with X-ray pulses, and a AeroDR fine FPD unit by Konica Minolta that enables dynamic imaging (Fig. 2). The government approval process was the same as for a regular general radiography system. There were no special requirements, such as a different installation notification form submission process to the Labor Standards Inspection Office or Public Health Center, for example. The greatest feature of this system is the ability to acquire multi-frame images like fluoroscopy, but by a radiographic system. Since our hospital has only a few radiography rooms, installing a system capable of both general radiography and also dynamic radiography allows us to introduce new technology without adding a new radiography room. That made this system attractive in terms of cost and resulted in our introducing this system.

Fig.2 Appearance and X-ray conditions of the system with Dynamic Radiography ability

3. System Configuration for Dynamic Chest Radiography

Our hospital installed this system with dynamic radiography capability in March 2017. Having approval from the Tokai University Ethics Committee, we started clinical trials of dynamic chest radiography with patient approval in January 2018. The system can perform dynamic radiography in a variety of situations, such as in standing, supine, or sitting positions, just like with a regular general radiography system, but with about 7 to 15 second exposures pulsed at 15 frames per second. Even at maximum, its radiation dose level is comparable to the total dose of the chest-frontal (ESD: 0.4 mGy) and chest-lateral (ESD: 1.5 mGy) in radiography guidance levels specified by the International Atomic Energy Agency. It results in a higher radiation dose than standard radiography, but it can acquire images for a wider range than other modalities, apply weight loads in body positions of daily life, and provide dynamic information about organ's shape or functional situation. **(Fig.3)** Therefore, we think those additional information is more valuable than the increased radiation dose.

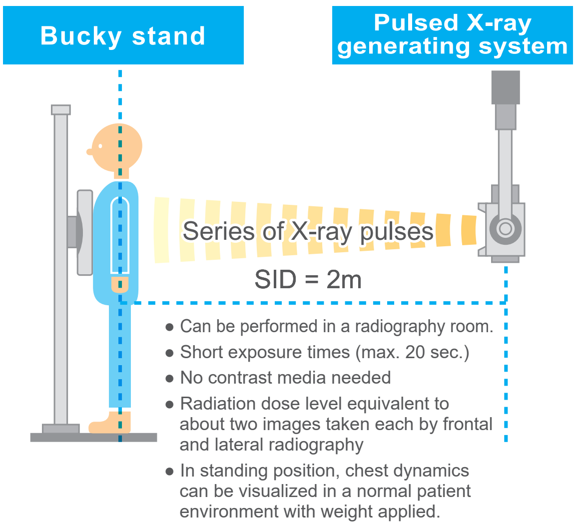


Fig.3 Characteristics of Dynamic Radiography

4. Method for Dynamic Chest Radiography

The main differences from regular radiography techniques are a longer exposure time and different breathing instructions. The exposure time is tenths of a second in regular radiography, on the other hand, it's a few seconds in dynamic radiography. Therefore, the steps performed by radiological technologists involve the same steps as regular radiography, plus additional steps specifically for dynamic radiography **(Fig. 4)**.

The first step is to explain the examination to the patient, which is very important. As the dynamic radiography requires patient action(movement), variations in that actions can significantly change examination results. Because the system resembles a regular radiography system, patients often assume they will receive a typical X-ray exam. Therefore, it is important to adequately explain that a dynamic radiographic examination is different from a regular X-ray examination and that the results will vary depending on how they breathe. Therefore, our hospital has prepared a leaflet for dynamic radiography examination guide and ask the patients to read it before the examination. This contributes to improve the patients' understanding and increase the efficiency of the radiography room by preparing the room while the patient is reading the leaflet **(Fig. 5)**

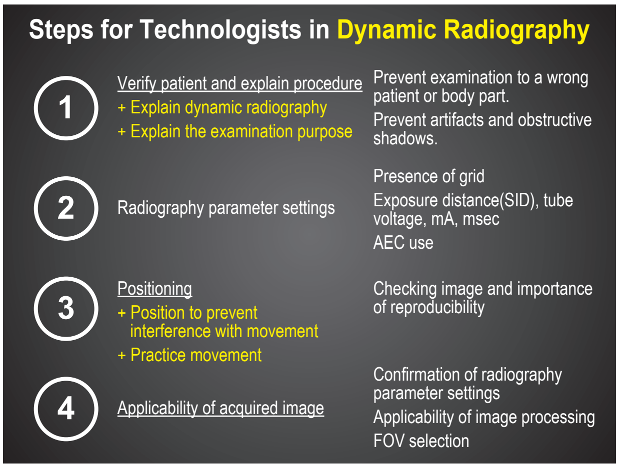


Fig.4 Steps for Radiological Technologists in Dynamic Radiography

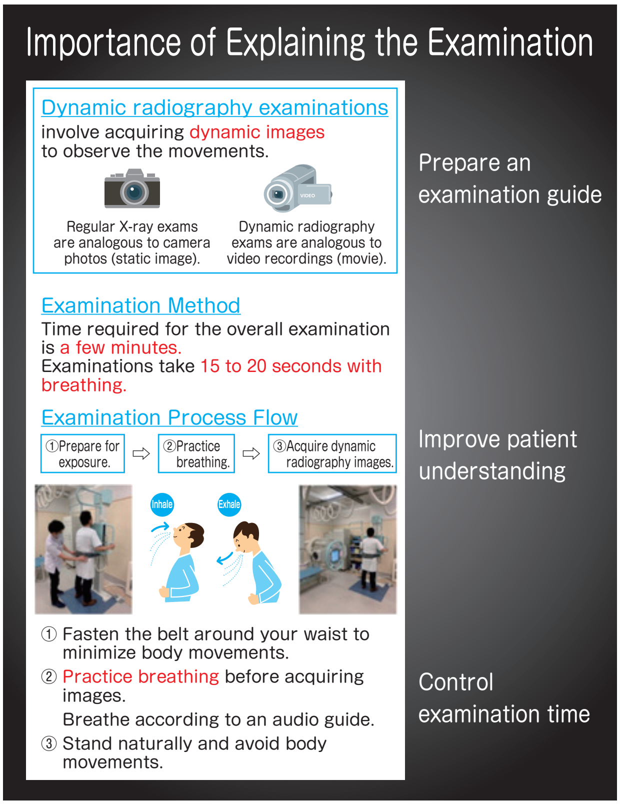


Fig.5 Dynamic Radiography Examination Guide

The second step is to position the patient. Current dynamic chest radiography studies focus on the motions of structural objects associated with breathing, thus it requires to minimize rolling or other body movements as much as possible. To inhibit it, we have a patient fasten a belt around their waist.

However, because restricting movement does not provide a natural environment, the belt must be positioned on with attention to the respiratory and accessory muscles. At our hospital, we try to keep patients in a relaxed position, rather than positioning them to avoid the shoulder blades, which is the positioning typically used for regular radiography (Fig. 6).

The third step is to give breathing instructions. A variety of breathing instructions are available, such as deep breathing, quiet breathing, or holding the breath, but and the exposure time and breathing instructions must be varied depending on the dynamic information needed. Currently, at our hospital, we instruct the patients to have deep breathing or hold breathing, but unlike regular radiography, the instructions are complicated (Fig. 7). Dynamic chest radiography examinations could also be used as functional examinations, so there is a possibility of performing examinations repeatedly. Considering the radiological technologist may not be always the same, it is essential to use an automated voice generating device ("auto-voice" device) to avoid variations in reproducibility by the verbal instruction by the technologists. Therefore, the patients of our hospital practice breathing with the auto-voice device after hearing our explanation prior to the examination. Such auto-voice devices are normally associated with the exposure switch, so that the voice cannot be generated unless the technologist goes out of the examination room, However, in the RADspeed Pro system that we newly introduced, the auto-voice is triggered by its activation button on the X-ray tube control panel, which means the technologist can remain close to the patient to confirm if the patient is following breathing instructions. That is an important and effective functionality to confirm not only to follow breathing instructions, but also to implement the safety measures and body movement restraints properly. (Fig. 8).

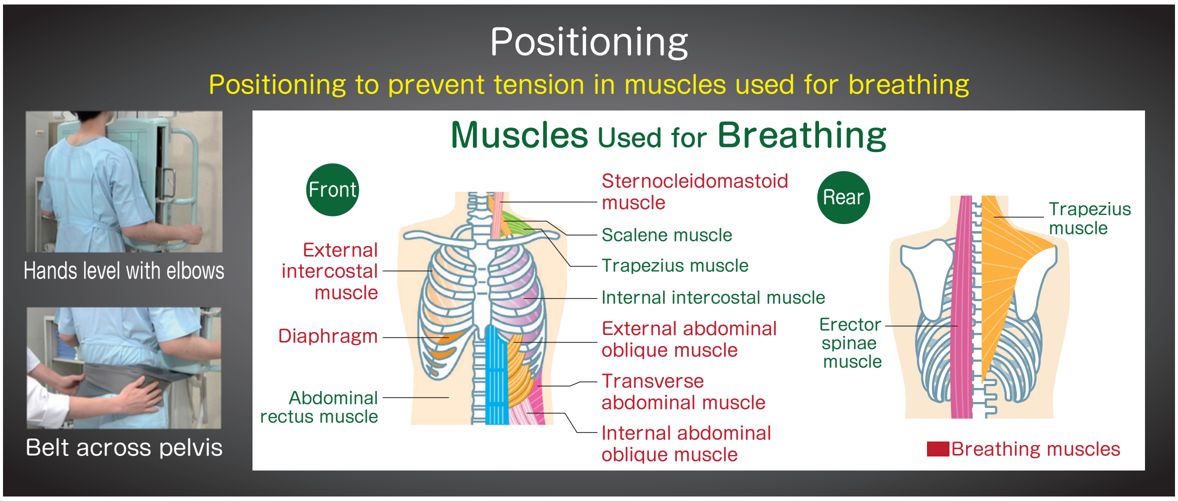


Fig.6 Positioning for Dynamic Chest Radiography

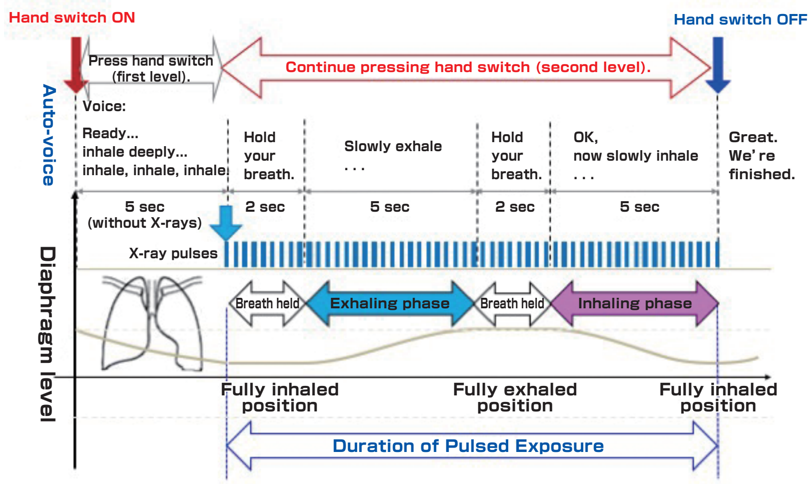


Fig.7 Deep Breathing Instructions and Exposure Timing

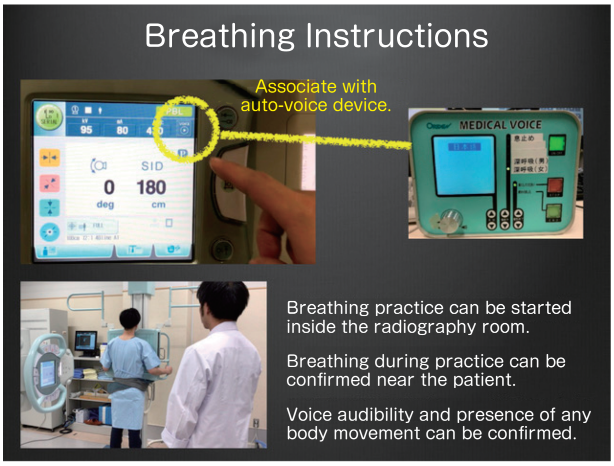


Fig.8 Auto-Voice Activation Button Used during Breathing Practice

5. Dynamic Radiography Data Analysis Technologies

After the image acquisition process, the data must be analyzed in the Konica Minolta KINOSIS dynamic X-ray image processing workstation, not in the main radiography system. A variety of analysis technologies is equipped in the workstation and the technology is advancing day by day. The current data analysis technologies can be generally classified either as dynamic chest imaging (DCI) for diagnosis for organs' shape or movement or as pulmonary functional imaging (PFI) for diagnosis based on function (**Fig. 9**). DCI can analyze the distance and the positional relationship of the structure that is fluctuating dynamically and can show the relation with the time axis which was impossible until recently. PFI can provide information about periodic movement by analyzing trends in pixel value variations. That allows observing periodic relationships with breathing and heartbeat cycles.

6. Clinical Example of Dynamic Chest Radiography

Though dynamic radiography images are difficult to present on paper because they involve a time axis, the following describes a clinical example of a procedure performed at our hospital. **Fig. 10** shows the positions of the right and left apices of the lung and the diaphragm detected from dynamic chest radiography images. **Fig. 11** is the chart to show how their detected positions vary during breathing. In healthy lungs, the left and right diaphragms move together, but in this case, the right diaphragm (blue line) moves poorly, resulting in opposite movement from the left diaphragm (green line). This condition can only be shown instantaneously and cannot be determined from a regular X-ray image.

Fig. 12 shows the extracted signals related to the fluctuation of pixel values in the lung field and the respiratory cycle. It shows the amount of signal change from the fully peak exhaled position, and the areas are colored in blue if the amount changes a lot. **Fig. 12a** is from a patient with normal respiratory function, whereas **Fig. 12b** is from a patient with chronic obstructive pulmonary disease. The images show that less change quantity can be found in the upper middle lung field of the patient with the lung disease. This suggests that the degree of signal variation from the lung tissue during respiration might differ depending on the disorder, which can be expected to improve our understanding of the pathology and help improve detection of lung disease.

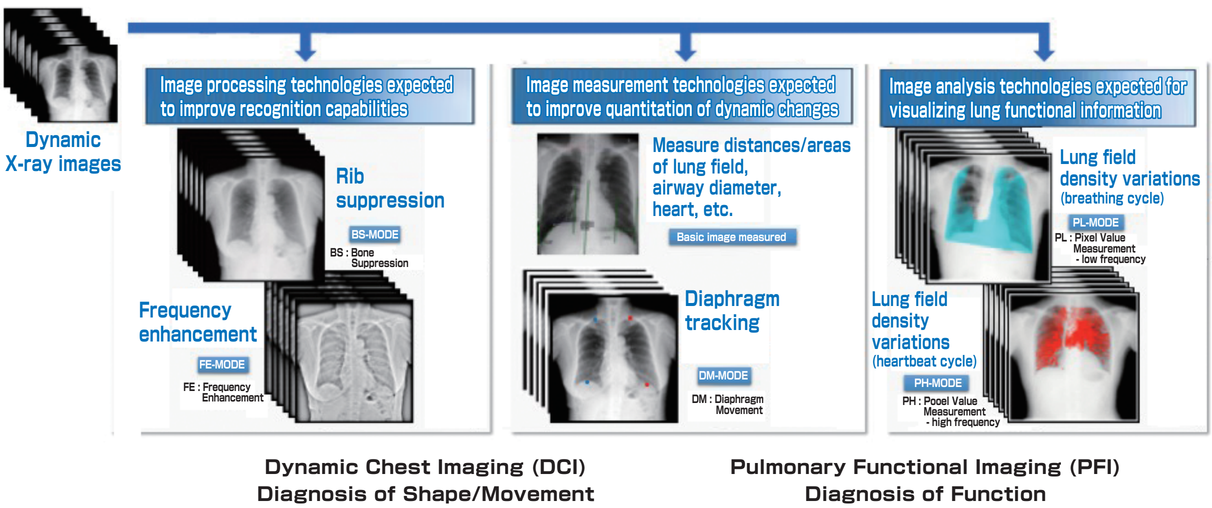


Fig.9 Dynamic Data Analysis Technologies

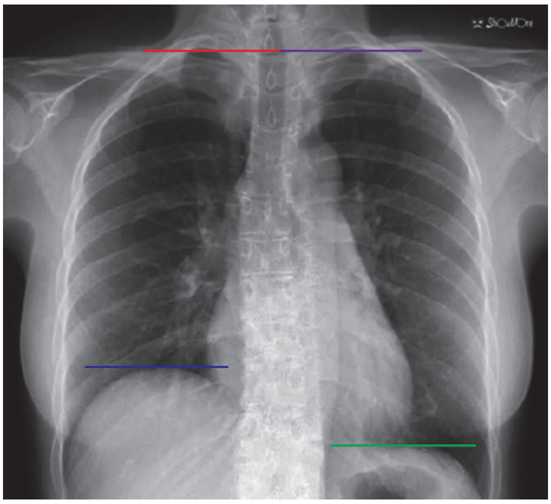


Fig.10 Position of Left/Right Lung Apex vs Diaphragm

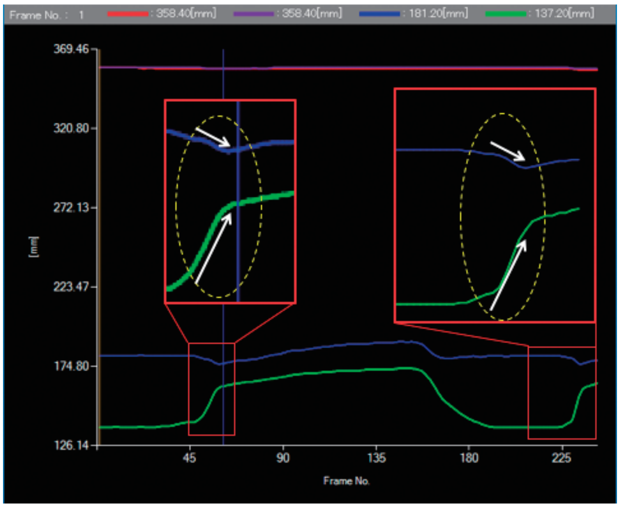


Fig.11 Height Variations Due to Breathing

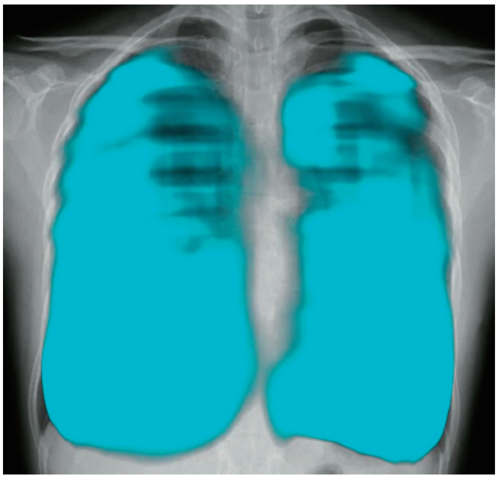


Fig.12 a) Patient with Normal Lung Function

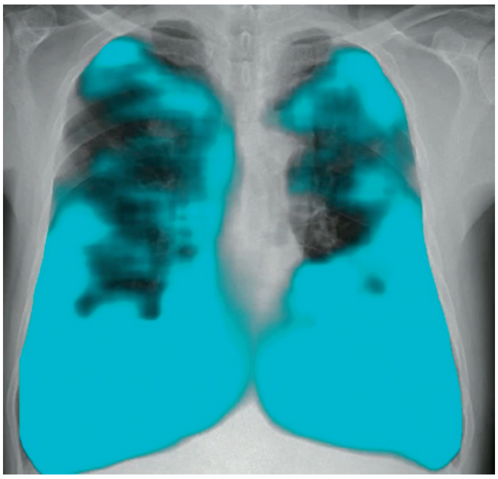


Fig.12 b) Patient with Chronic Obstructive Pulmonary Disease

7. Summary

Currently, the clinical researches of the dynamic radiography are proceeded in a wide variety of facilities, and its correlation with the nuclear medicine examinations has been recognized not only in animal studies but also in actual clinical studies, and r its value has been found in clinical field. The biggest advantage of dynamic radiography is its convenience. The dynamic radiography system we introduced can be used just as an extension of a general radiography system. Consequently, there has been little resistance from radiological technologists, who use radiology the most often. The minimal invasiveness and functional examination capability also offer revolutionary improvements in physical stress and cost for patients. Due to its low cost and simplicity of enabling functional examinations, the potential demands for dynamic radiography systems are presumably high, not only among large hospitals, but also among smaller hospitals without nuclear medicine or CT . Use of dynamic radiography is expected to expand in the future for a wide variety of applications and other body areas. Consequently, it might even go beyond being simply another examination framework. That would require various knowledge and experience. From a multifaceted perspective, it’s possible that the new unique imaging methods of dynamic radiography will be developed. As medical imaging continues to transition from still images to dynamic imaging, radiological technologists will also need to increase their knowledge of physiology and functions so that they can better understand and comment on clinical information obtained from dynamic images.

Stories of Kyoto-born Masterpieces — ㉓

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

Delicate *unkin* patterns have been chiseled into a pure silver kettle (right). While working on other projects, only one of these unique pieces can be made a month.

Kyo-kazari — Decorative Fixtures

Kazari-shi — also known as *kazari-shoku* or *kazari-ya* — are expert craftsmen who work metals such as gold, silver, and bronze to create decorative metal fixtures for shrines and temples, Interior fittings, and family altars. Formerly, *kazari-shi* were counted alongside carpenters, plasterers, stonemasons, and roofers as one of the five artisans involved in building the Kyoto Imperial Palace. Of course, Kyoto is also home to many shrines and temples, and so in the past, numerous *kazari-shi* were active in the city. Today, *kazari-shi* are in charge of creating, repairing, and restoring gate doors, nail covers, sliding door handles, fixtures for folding screens, and more for various shrines and temples. Moreover, they are also engaged in the creation of decorative fixtures for floats at the Gion Festival, tools for the tea ceremony, fixtures for picture mounts, Japanese armor, and other items that can only be made by hand.

Some representative examples of metalworking include chasing, in which the surface of a piece of metal is decorated using delicate chisel patterns; forging, in which blocks or sheets of metal are hammered into shape; and casting, in which the metal is shaped by heating and melting it into molds. While usually each one of these styles is the trade of a dedicated craftsman, *kazari-shi* can undertake all of these roles at once. On occasion, they can work together with these experts to create a single piece, overseeing the entire process.

Switching tools and gradually shaping

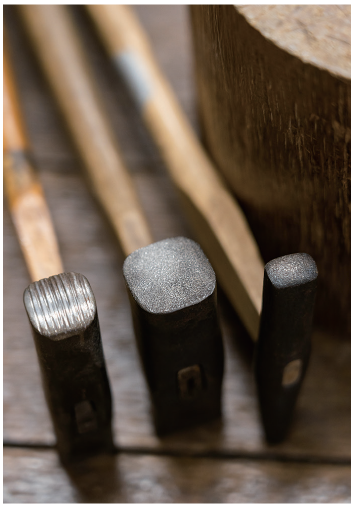
Gold, silver, bronze, tin, and iron are the five main metals used in metalworking. When using silver, the initial sheet must be big enough for the entire surface area of the resulting product. In the case of a sake cup around 6.5 cm in diameter and weighing 594 g, a 11 cm circle is drawn onto a 0.6 mm thick sheet of silver before being cut out. To give the rim of the cup a certain thickness and make it more resistant to cracks, the outer edge is then hit with a metal hammer in a process known as *yose*. Next is the annealing process, during which the metal is heated with a burner at around 600–800°C and then quickly cooled in water to make it soft enough to bend by hand. The metal is then placed on a wooden work stand and hit with a wooden hammer all over before being gently curved with a metal hammer. Hitting the soft metal with a hammer causes the metal molecules to compress resulting in a denser, harder material.

The metal is once again annealed and rapidly cooled, and this time it is shaped on a wooden work stand using a dolly and either a wooden or metal hammer to gradually reduce the diameter of

The metal is annealed with a burner for around 15 seconds before being quickly cooled in water.

The metal is placed on the craftsman's lap and the edges are carefully hit with a metal hammer.

After the metal has been annealed once, it is placed on a wooden work stand with a dolly and the edges are raised using both wooden and metal hammers.



The hammer patterns give the final piece a personality of its own. The metal hammers are handmade by each generation of craftsman.

In metalwork chasing, among others, the metal can be chiseled or embossed. Inlaying the chiseled portions with other materials is another metalworking technique.

In 2004, Chikueido's drawing room was converted into a store—Kazariya Ryo. Up-and-coming craftsmen make bookmarks, netsuke sculptures, and other small items which are sold in store.

the rim. Repeating this process slowly raises the edges of the metal, but maintaining the metal at its original 0.6 mm thickness is no easy task. As the diameter can only be reduced by 5-6 mm at a time, craftsmen must patiently and delicately switch the use of metal and wooden hammers depending on the part being hit, the surface area, and the desired finish.

Changing times and changing roles of *kazari-shi*

While there is still demand for certain decorative metal fixtures in temples, shrines, and other structures, the use of some metal fixtures has been lost to time. One of these is sword decorations. The wealth of *kazari-shi* techniques used to create handguards, hilts, handle fittings, blade fittings, and other components of swords are said to have kickstarted a unique Japanese metalworking culture. However, when an edict to abolish the use of swords was issued in the Meiji period, numerous *kazari-shi* lost their jobs. Later, *kazari-shi* moved onto decorating *kiseru* smoking pipes, which were hung from the waist, but as rolled cigarettes gained in popularity, *kazari-shi* once again had to look elsewhere for work.

Chikueido was established in the Kanei era, and has held a workshop to the south of the Kyoto Imperial Palace for more than 130 years. The workshop is currently headed by 7th-generation *kazari-shi* Chikueido Eishin. The family were long involved in the creation of sword decorations, but since the Meiji period, have predominantly been producing tools for Japanese incense and tea, as well as Buddhist altar fittings. "Although general use of *kiseru* pipes and *koro* incense burners has ceased, we still produce them for use in the tea ceremony or as Buddhist fixtures," says Chikueido, who also takes part in the tea ceremony himself to help him with his creations. "There are many things I've learned by taking part in the tea ceremony, and I continue to be charmed by the depth of the tools used." Although his specialty is forging, naturally, as a *kazari-shi*, he is also skilled at chasing and casting. "Finding ways to bring out the innate beauty of the metal is the job of a *kazari-shi*." Chikueido is in constant pursuit of the beauty of everyday objects.

Chikueido himself teaches at the Traditional Arts Super College of Kyoto, and he is focusing on nurturing the next generation of *kazari-shi* by hiring graduates from the college. "It is my hope that the job of the *kazari-shi* can continue long into the future." Future *kazari-shi* are waiting in the wings at Chikueido.

Special thanks to: Chikueido; http://www.chikueidou.com/

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