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Minimally Invasive Procedures in Practice

—Effort by Fukuoka Kieikai Hospital Part 1—

Medical Systems Division, Shimadzu Corporation

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Given the increasingly complex and sophisticated interventional procedures in recent years, users are requesting angiography systems that can achieve lower X-ray dose levels, less required contrast agent, and shorter examination times. Shimadzu's latest Trinias series angiography system features various functionality for achieving minimally invasive procedures.

To highlight uses of various functionality for neurointerventional radiology, this article is the first of two parts describing the measures at Fukuoka Kieikai Hospital.

1 Using the Virtual Stent Function

Fukuoka Kieikai Hospital uses the virtual stent function for carotid artery stenting (CAS). The virtual stent function displays virtual stents in blood vessels shown in a 3D images, based on the specified stent size (length and diameter). Unlike functionality that only performs measurements, this function enables visual confirmation of the stent implant location and post-implant coverage range **(Fig. 1)**.

Fukuoka Kieikai Hospital not only anticipates using the function for CAS procedures, but also for stent-assisted coiling of cerebral aneurysms **(Fig. 2)**. For such procedures, it is extremely important for the stent to adequately cover the neck portion of aneurysms, which can be confirmed visually using a virtual stent. We received feedback that It tends to overestimate the length in a bent vessel, but being able to visually confirm the coverage with a virtual stent is more than adequately beneficial."

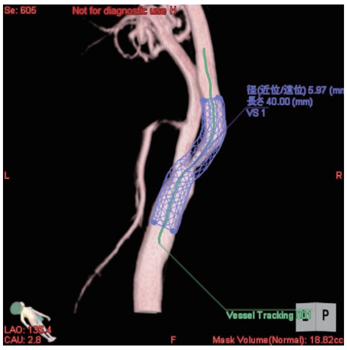

Fig. 1 Example of Using Virtual Stent Function for Stenosis at the Origin of the Internal Carotid Artery

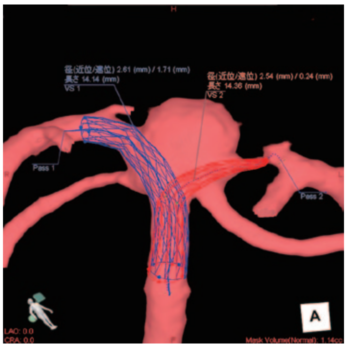

Fig. 2 Illustration of Using Virtual Stent for Coil Embolization of Cerebral Aneurysm

2 Utilizing Blood Vessel Measurement Functionality

In many cases treating cerebrovascular diseases , such as carotid stenosis or cerebral aneurysms, requires measuring vessel diameters and distances in multiple locations.

Normally, such diseases are measured using relatively simple distance measurement functionality, but Fukuoka Kieikai Hospital uses the vascular measurement functionality in SCORE 3D workstation, especially for CAS procedures. That functionality automatically analyzes the major and minor diameters at any cross section of the specified blood vessel and the distances

A Word from Osamu Ito, M.D., Ph.D., Department of Neuroendovascular Surgery

After using the Trinias series unity edition angiography system for the first time, I was very surprised by the excellent image quality. When I learned that it is based on Shimadzu's proprietary state-of-the-art image processing technology, such as Flex-APS,[a] it really renewed my appreciation for Shimadzu's high technical capabilities.

We are also very satisfied with the excellent functionality and user-friendly operability of the 3D workstation software featured in this article (SCORE 3D workstation). Needless to say, the high image quality and image guidance function will result in more advanced interventional procedures. I also look forward to additional system advancements being introduced in the future.

[a] (Excerpt by Editorial Team) References: Shohei Okubo et al. Shimadzu Review, Vol. 74, No. 1 and 2, pp. 81-84, 2017

between measurement points and then displays a summary of the measurement results within a single screen **(Fig. 3)**. In the case of CAS procedures, for example, it can also simultaneously analyze the blood vessel diameter at the lesion area, the vessel diameter at a reference point, the distance between reference points used to determine the length of the stent to be implanted, and the vessel diameter at the position where the protection device is to be implanted. Specifying the blood vessel to be analyzed involves simply plotting two points.

We received feedback that “The functionality is very convenient, because almost all the information necessary for treatment can be understood at a glance using simple operations using that functionality.” The functionality can also be used to analyze stenosis.

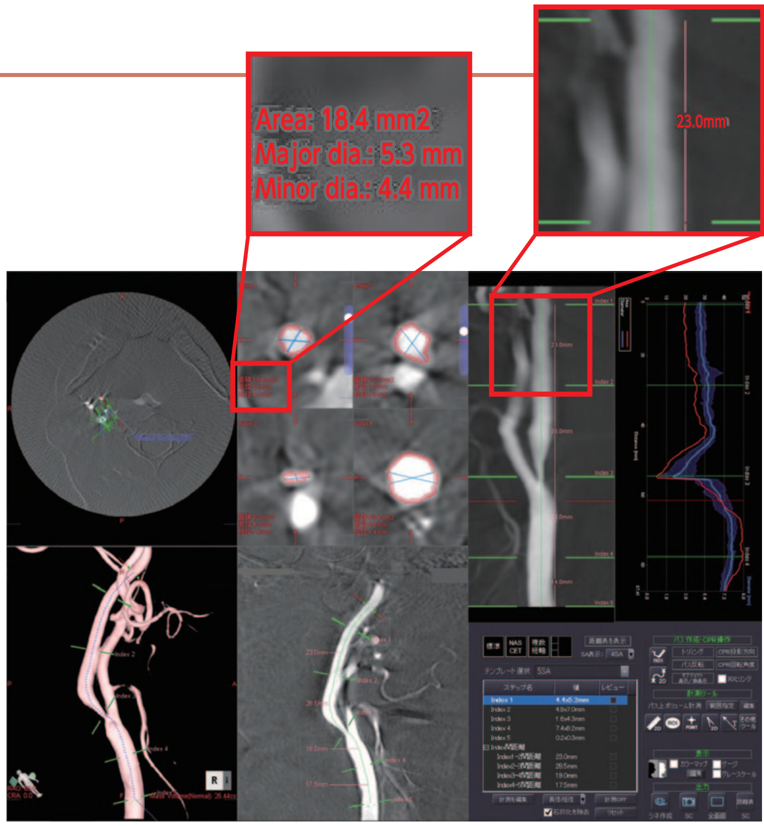

Fig. 3 Vascular Measurement Screen

This screen includes a consolidated display of axial, 3D, short axis MPR (cross-section along short axis), CPR, straight view, and diagram images. Also, measurement points are indicated in all views to enable easier visual confirmation.

3 Utilizing Multiple Functions for Reviewing Working Angles

Using an appropriate working angle for coil embolization of cerebral aneurysms is an important element for maximizing therapeutic benefits. Furthermore, because the angle is determined during the procedure on the day of surgery, it needs to be determined as quickly as possible.

To determine the appropriate working angle quickly, Fukuoka Kieikai Hospital uses a combination of two functions. The first is the 3D image transparent display mode **(Fig. 4)**. The transparent mode displays blood vessels with semi-transparency, which is helpful for understanding how the blood vessels overlap in the depth direction. The second is the 3D dual-display mode. Trinias series systems can simultaneously display up to four 3D images, but they use the dual-display mode to quickly decide the working angles of both planes on the same screen **(Fig. 4)**.

They also use three rotation dials for angle adjustments **(Fig. 4)**. Because 3D images can be freely rotated using the mouse, it may seem difficult to determine the working angles while taking into consideration the C-arm movement range. In contrast, it seems much easier to determine working angles while taking into consideration the C-arm movement range by using the dials, which enable the angle to be adjusted to only one direction. Once working angles are determined, the angle transmission function is used to send the angles to the C-arm.*1 Specifically, the workflow consists of “using the left-right dial to adjust the orientation around the body axis (LAO/RAO), using the up-down dial to adjust the orientation in the body axis direction (CRAN/CAUD), using the mouse to make fine adjustments to the working angles, and then sending the angles to the C-arm.” The workstation software also includes an angle memory function that can record multiple working angles for easy recall later **(Fig. 5)**.

Fig. 4 Dual-Display and Transparent Display Modes

The frontal plane working angle is determined on the left side and the lateral plane working angle is determined on the right side. The dials are located in the lower right corner of respective views and can be used to adjust the corresponding angles in longitudinal and lateral directions.

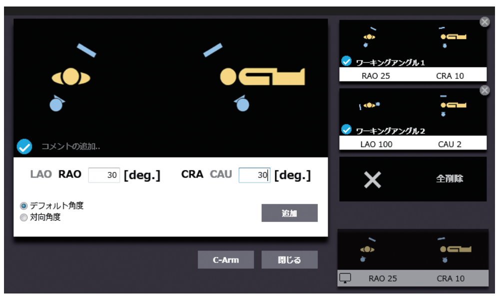

Fig. 5 Angle Memory Function

Angles can be recorded in the thumbnails on the right.

*1: The angle transmission function is only enabled for the frontal C-arm.

R/F

Cutting Edge of ERCP
—Experience Using the SONIALVISION G4 and Reducing Scattered Radiation Dose Levels

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Yoshitaka Nakai

On October 4th, Shimadzu and the Japanese Society of Radiological Technology joinly held a luncheon seminar at the 46th Autumn Scientific Congress of (from October 4 to 6, 2018). Hiroshi Hirano, R.T. (Director, Clinical Technology Department, Marunouchi Hospital) chaired the seminar, and Yoshitaka Nakai, M.D. (Deputy Director, Department of Gastroenterology, Digestive Disease Center, Kyoto Katsura Hospital) gave a presentation entitled “Cutting Edge of ERCP.” This article provides an overview of that presentation.

1. Introduction

As you know, ERCP is an acronym for Endoscopic Retrograde CholangioPancreatography. ERCP has a long history, and in 1968, Dr. William S. McCune of the United States was the first to successfully produced a contrast image of the pancreatic duct[1). This is the origin of ERCP, the year of 2018 is the 50th anniversary since ERCP was developed. In 1969, the year after the first successful pancreatography, Oi[2)], Takagi[3)], et al succeeded in the first pancreatography in Japan. Later, as additional techniques and devices related to ERCP were developed, the method became an essential examination method for diagnoses and procedures for disorders of the biliary tract and pancreas. However, even though ERCP has a long history as an examination method, diagnostic ERCP involves a risk of accidental postoperative pancreatitis. Consequently, ERCP is often substituted in recent years with MRCP or endoscopic ultrasonography (EUS), which can now be used to diagnose many disorders.

This article reports on our current status of ERCP at our facility, cooperation with radiological technologists, measures to reduce scattered radiation dose, and our experience using a Shimadzu SONIALVISION G4 Multi-purpose Digital X-ray R/F system.

2. Current Status of ERCP at the Digestive Disease Center

Our hospital, which is located in the Nishikyo Ward of Kyoto City and is a facility with 585 licensed beds, mainly provides acute care and regional cancer treatment center for the western part of Kyoto City, Kameoka City, and the Otokuni region **(Fig. 1)**. The Digestive Disease Center is divided into departments for internal medicine and surgery, and the internal medicine department is further divided into departments for gastrointestinal, hepatic, biliopancreatic, and chemotherapy. The Digestive Disease Center is also designated as an instructional facility for the Japanese Society of Gastroenterology, Japan Gastroenterological Endoscopy Society, and the Japan Biliary Association. The biliopancreatic department performs procedures related to biliary and pancreatic systems, including outpatient and inpatient ERCP and endoscopic ultrasonography examinations under the supervision of three advising physicians.

Fig.1 Hospital Information

Though the need for diagnostic ERCP is declining due to the introduction of MRCP and endoscopic ultrasonography, the number of ERCP examinations at our center is almost flat **(Fig. 2)**. That is probably due to the aging of the population and an increase in emergency patients and biliary tract cancer patients after the hospital strengthened emergency medical care capabilities and cancer treatment partnerships. It seems to be in the similar tendency nationally, because the aging will advance further in future.

During the period from January to December 2016, our facility treated 326 ERCP cases (with an average age of 74.2). Out of those, 44 % involved disorders related to stones in the biliary tract and 40 % involved malignancies, including pancreatic and biliary tract cancers **(Fig. 3)**. In the case of biliary tract stones, common bile duct stones are mainly treated with endoscopic sphincterotomy (EST) and endoscopic stone removal and the cholangial drainage is performed for acute cholangitis. For malignancies, pancreatic juice aspiration cytological examination for early diagnosis of pancreatic cancer, a definitive diagnosis or a disease range diagnosis for biliary tract cancers, or a stent implantation for obstructive jaundice are treated. In addition, we remove pancreatic stones or implant stents in the pancreatic duct for chronic pancreatitis. We also handle acute cholangitis cases that require emergency drainage 24-hour a day. In fact, in our center in 2016, the proportion occupied by emergency ERCP cases was 17.5% of the whole. The number of these cases is expected to increase nationwide as the number of patients with biliary tract stones increases due to aging.

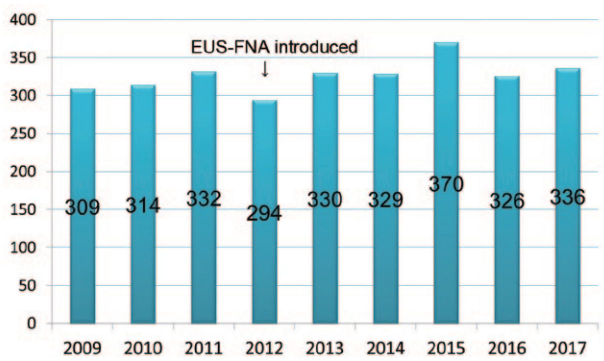


Fig.2 Total ERCP Cases at the Digestive Disease Center by Year
Number of ERCP examinations did not decrease even after advancements in MRCP or introduction of EUS-FNA.

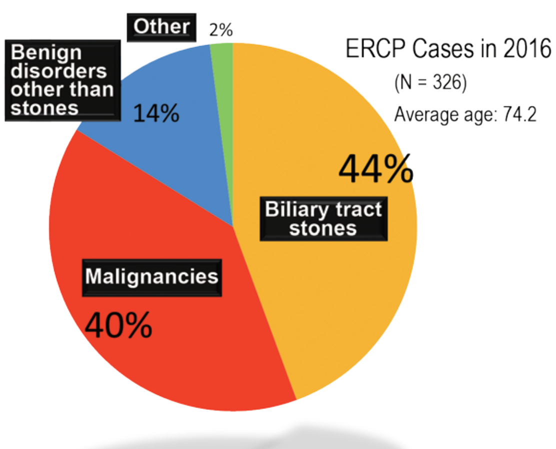


Fig.3 ERCP Cases in our facility in 2016 by Disorder Type

3. Cooperation Between Radiological Technologists and Endoscopists

Even in the emergency, ERCP is carried out in the system of over four medical professionals of a physician, assistant, nurse, and radiological technologist in our facility. Currently, at almost all facilities, the physician is the person that actually operates the X-ray R/F system, even at high-volume facilities in the Kyoto-Shiga region. Normally we always assign an appointed radiological technologist to every ERCP procedure, and the merit is explained as follows. During examinations, since the physician focuses on operating the endoscope, watching the fluoroscopy monitors, and monitoring vital signs, the more difficult the examination is, and the more inexperienced the physician tends to narrow his field of vision. It is easy to imagine that the field of view becomes narrow further more when the operation of the X-ray R/F system is added. It is considered that it inevitably leads to increase of fluoroscopic dose and scattered radiation exposure dose and overlooking of the accident diseases. For that reason, our facility assigns an appointed radiological technologist. Their role is not only to manage the X-ray R/F system but also to accurately depict fluoroscopic images and imaging positions required by physicians by sharing examination procedures before examination. Therefore, the switching of the fluoroscopy on/off and the switching of the fluoroscopy mode can be performed at an appropriate timing, to avoid unnecessary fluoroscopy by the operator and to reduce radiation dose levels. They also use fluoroscopic images during and immediately after the examination to confirm location of the device or lesion in a wide field of view and contingencies such as "free air" or leakage of contrast material. Technologists are also in charge of managing spot and dynamic images (fluoroscopic and endoscopic) and managing fluoroscopy exposure times. We believe that cooperation between the physician and an appointed radiological technologist is important for achieving safe, smooth, and less stressful examinations.

4. Measures to Reduce Scattered Radiation Dose Levels

If multiple ERCP examinations are required in the same case, the same physician, assistant, and nurse are assigned. Therefore, it is extremely important of countermeasures against radiation exposure of patients and the scattered radiation exposure of the medical personnel. Measures at our facility include (1) enhancement of lead X-ray protective gear, (2) reconsidering the X-ray parameter settings for X-ray R/F system, and (3) assigning appointed radiological technologists, as previously mentioned. Initial countermeasures in 2008 was only a protective apron, but later a neck guard and protective glasses were prepared. Then in 2015, protective cloth barriers (protection on four sides equivalent to 0.25 mmpb of lead, manufactured by Hoshina Co., Ltd.) were introduced over the X-ray R/F system to block scattered radiation **(Fig. 4)**. The scattered radiation protective cloth involves is used by directly covering the X-ray tube with a mesh-like cover, and suspending the lead protective cloth on the four sides with fastener tape. It is said to reduce scattered radiation levels by about 80 to 90 %.[4)]

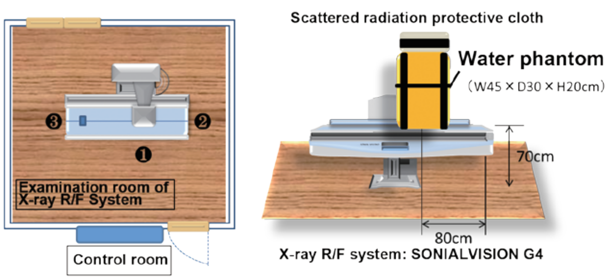
The measurement parameters and methods used to measure the effectiveness of the scattered radiation protective cloth installed at our facility is shown in **Fig. 5**. It reduced scattered radiation dose levels at the position of the physician by 87.1 %, at the position of assistant (2) at the head end by 66.6 %, and at the position of assistant (3) at the feet end by 62.0 % **(Table 1)**. It is particularly effective for the physician position, probably due to the higher scattered radiation levels near the X-ray tube.

We also examined the scattered radiation reduction levels for a variety of fluoroscopy parameters. Changes in scattered radiation levels were measured after changing filter thickness from 0.1 to 0.3 mm Cu and the pulse rate from 15 to 7.5 fps in X-ray R/F X-ray parameters. Decreasing the pulse rate reduced the scattered radiation dose level by up to 48.2 %, increasing the filter thickness reduced it by up to 55.3 %, and combination of decreasing the pulse rate and increasing the filter thickness reduced it by up to 76.0 % **(Table 2)**.

The condition of desirable fluoroscopy image required in ERCP are "good visibility" of endoscopy guide wires and devices, "excellent trackability" for the fluctuation of the respiration and the movement of the guide

Protection on four sides equivalent to 0.25 mmpb of lead, manufactured by Hoshina Co., Ltd.

Fig.4 Enhancements of Lead X-Ray Protective Gear



Irradiation field: 12 × 12 inches
Measurement points: ❶ Physician, ❷ Assistant 1, and ❸ Assistant 2, about 80 cm above the floor
Remarks: Assumes ERCP use
(tabletop height = 70 cm, center of X-rays = 80 cm from tabletop edge, toward ❷ (Assistant 1))
Measuring device: X-ray dosimeter
(survey meter model: 451B-DE-SI-RYR, S/N: 1501)

Fig.5 Measurement of Air Dose Level in R/F Room

Table 1 Effectiveness of Scattered Radiation Protective Cloth in Protecting against Scattered Radiation Dose
X-ray parameters: 93 kV/9.2 mA, 15 fps pulse, 0.1 mm Cu filter

Scattered Radiation Protective Cloth	Measurement Value (μSv/h)		
	❶	❷	❸
Without	5600	900	290
With	720	300	110
Reduction (%)	**87.1**	**66.6**	**62.0**

❶ Physician, ❷ Assistant 1, ❸ Assistant 2

Table 2 Reduction of Scattered Radiation Dose By Pulse Rate and Filter Thickness

X-Ray Parameters (kV/mA)	Pulse (fps)	Filter (mm Cu)	Measurement Value (μSv/h)			
			❶	Reduction	❷	❸
Pulse 15 N 93 / 5.2	15	0.1	5600 (720)	–	900 (300)	290 (110)
Pulse 7.5 N 93 / 2.6	7.5	0.1	2900 (310)	48.2%	420 (156)	148 (56)
Pulse 15 L2 90 / 4.2	15	0.3	2500 (300)	55.3%	400 (155)	135 (54)
Pulse 7.5 L2 90 / 2.1	7.5	0.3	1340 (162)	76.0%	210 (76)	69 (30)

❶ Physician, ❷ Assistant 1, ❸ Assistant 2, measurement values with scattered radiation protective cloth indicated in parentheses wires, and "high resolution" biliary and pancreatic duct images for diagnostics **(Fig. 6)**. It is important to select the optimum fluoroscopic conditions based on examination contents and the purpose at the time in order to secure the quality of the examination and to reduce the exposure to scattered radiation.

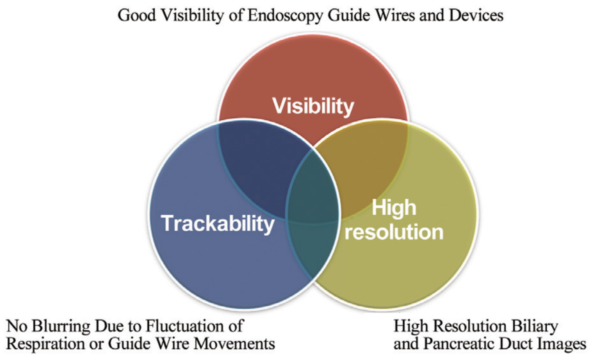


Fig.6 Desirable Fluoroscopy Image Required in ERCP

5. Experience Using the SONIALVISION G4

In our facility, Shimadzu SHIMAVISION POWER PRO system had been used as a X-ray R/F system for endoscopic diagnostic imaging and procedure, but Shimadzu SONIALVISION G4 system was newly introduced in October 2016. Our impressions from using the system were that (1) image quality and visibility were significantly improved, (2) two 19-inch LCD monitors installed in the examination room enabled to compare the fluoroscopy and radiography images and enable to ensure sufficient working space for examinations by the space saving design **(Fig. 7a)**, and (3) the process of recording, saving, and processing images was simplified. Though it is easy to forget the benefit of the good image quality, when it gets used to new X-ray R/F system, the difference in image quality is clear at a glance, when comparing it to the previous system. It also results in less eye fatigue after examinations and shorter examination times.

In the previous system, DVD recorders were required for both endoscopic and fluoroscopic images, respectively, and that caused various problems, such as recording errors, DVD media storage space requirements, and the time consuming for checking videos. Since SONIALVISION G4 is linked with the desktop computer located inside the control room, the endoscopic images and fluoroscopic images are displayed on the same sub-monitor screen using a picture-in-picture display mode **(Fig. 7b)**. Consequently, we can now record both endoscopy images and fluoroscopy images with the same time axis with a single click. That has eliminated recording errors and made it easy to check video images or process images immediately after examinations. That is not only helpful for checking procedures, but also for teaching and advising. Also, switching from using DVD media to using an external hard drive for recording video images has enabled to store large amount of images in a small space.

Meanwhile, when reducing fluoroscopic exposure with the previous X-ray R/F system tended to rely on a reduced pulse rate, or on a recursive filters which improve the graininess under low dose. That left problems in trackability for quick movements of guide wires or devices and in visibility of fluoroscopy images, due to image lag. The SONIALVISION G4 is equipped with SUREengine FAST (high-speed fluoroscopy image processing), which can reduce the radiation dose levels by image processing without decreasing the pulse rate. Since September 2018, the Super Low Dose mode has been installed in this system to further the reduce fluoroscopic exposure. The experience of it is described below.

Fig.7(a) 19-Inch LCD Monitors
Enables comparison of images

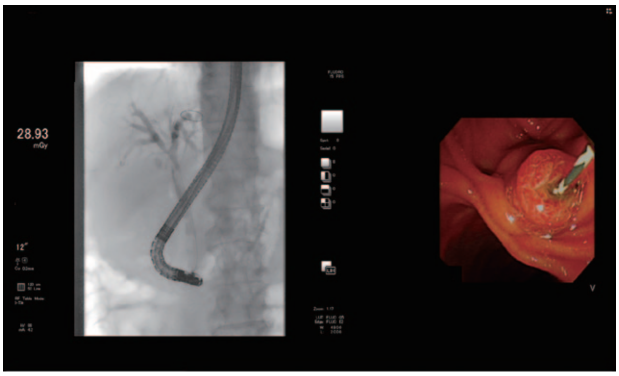


Fig.7(b) Picture-in-Picture System (Shimadzu System Development Corporation)
This simplified the process of recording, saving, and processing images.
The ability to record fluoroscopy and endoscopy images on the same time axis makes it easy to understand positional relation with lesions.
Replaying the images immediately after examinations is helpful for checking procedures and for use in training or advising.

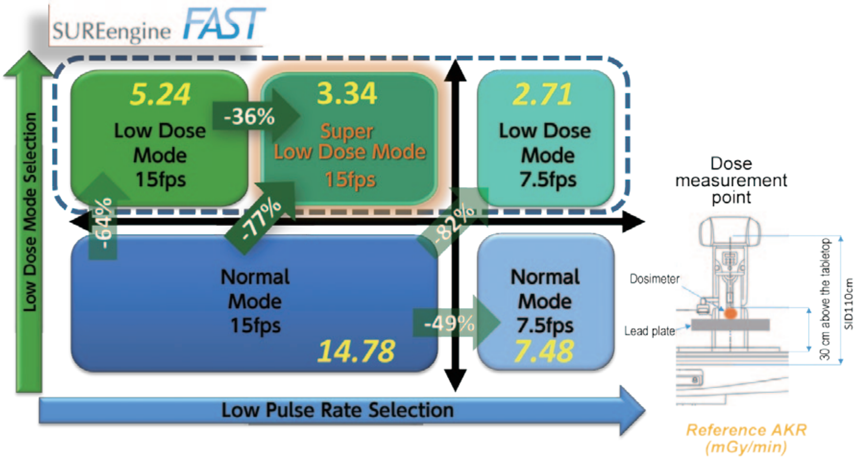


Fig.8 Comparison of Radiation Dose (AKR) for Each Fluoroscopy Mode

At our facility, we found that the Super Low Dose mode can reduce radiation dose by 77 % **(Fig. 8)** compared to the Normal mode (for pulsed fluoroscopy at 15 fps) given the same pulse rate. In terms of image quality, it also significantly improved trackability compared to pulsed fluoroscopy at 7.5 fps, which eliminated any image problems during normal guide wire operations or plastic stent placement in biliary ducts, for example. In addition, to improve visibility for metal stents in the biliary duct, baskets for removing stones, microliths, and so on, fluoroscopy parameters are adjusted according to the situation, as mentioned above. In the future, further image quality improvement is expected, while low radiation dose levels is maintained in calculus treatment or implanting metal stents.

6. Summary

ERCP, which has a 50-year history, will continue to be an essential examination method for early diagnosis of cancers in the biliary tract or pancreas and for emergency drainage during acute cholangitis. In order to carry out ERCP examinations of safely, smoothly, and less stressfully, the cooperation with a radiological technologist is necessary.

To reduce scattered radiation exopsure, we think it is important to enhancement of the use of lead protective gear and to optimize fluoroscopic condition for the X-ray R/F system. The introduction of SONIALVISION G4 system at our facility is improving the quality of examinations, and we expect Shimadzu to continue developing technologies to further reduce radiation dose levels and improve image quality with good visibility in the future as well.

1) Nobuyoshi Kuno, Ed., Basic Procedures and Applications for ERCP, KINPODO, Inc., 1994
2) Itaru Oi, Endoscopic Pancreatography by Fiberduodenoscope (FDS-Lb), Journal of Japanese Society of Gastroenterology 66; 880-883, 1969
3) Takagi,K., et al. Retrograde pancreatography and cholangiography by fiber duodenoscope. Gastroenterology.59;445-452,1970
4) Minami T,et al. Occupational Radiation Exposure during Endoscopic Retrograde Cholangiopancreatography and Usefulness of Radiation Protective Curtains. Gastroenterology Research and Practice.13:1-5,2014

SONIALVISION G4 USERS' VOICE
Kyoto Katsura Hospital (Kyoto Prefecture)

Low Dose Mode of SUREengine FAST Highly Rated for Use in Biliopancreatic Endoscopy

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■ Biliopancreatic Endoscopy at Kyoto Katsura Hospital

Our SONIALVISION G4 system ("G4" below) has been used for 600 examinations per year, including colon examinations. Almost 400 of those cases involved examining the pancreaticobiliary system, mostly for endoscopic retrograde cholangiopancreatography (ERCP).

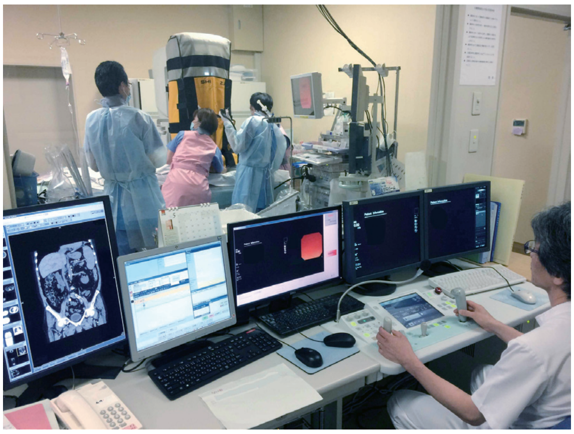
The role of the radiological technologist during pancreaticobiliary examinations is to manage the system and control image quality, of course, but it is also especially important to work in a closely coordinated manner with the assigned physician during examination. Therefore, a radiologic technologist is always assigned to all ERCP procedures. We have three appointed radiological technologists available, except on holidays, at night, or for emergency examinations or procedures.

■ Improvements in Pancreaticobiliary Endoscopic Examinations after Introducing the G4

Whenever the assigned physician changes or the system is replaced, the radiological technologist confers with the physician in advance to decide image sizes, left-right inversion, negative/positive display modes, and other details. Currently, we use a 12-inch field-of-view size for ERCP procedures, with fluoroscopy images in AP mode and positive-display mode, with radiography images in the negative-display mode. Settings for ERCP and other examinations are managed by using the G4's Procedure function, which can specify all program settings at once for each examination and also automatically configure X-ray parameters. Even if an appopinted technologist is not available, initial settings can be configured by selecting the Procedure. During ERCP procedures, typically, patients are positioned head down on the tabletop, so the AP image is displayed so that the physician does not feel discomfort when the eyes are moved from the endoscopic image to fluoroscopic images.

We think the position of the monitor is especially important for ERCP procedures. When the G4 was installed, the position of monitor in the examination room was arranged so that the fluoroscopic image could be seen immediately with minimum movement of the eye line from the endoscope image.

We also have introduced the picture-in-picture function for recording video images. During ERCP procedures, fluoroscopic images are output from the G4 system and



saved together with the endoscopic image as a picture-in-picture video image on the computer. Previously, endoscopic and fluoroscopic images were saved separately, which involved an extremely tedious and time-consuming process, but now that we can record video with both modalities synchronized it is much more convenient. The video can be replayed immediately, so physicians can watch the video to review the procedure after examination. For example, they can learn from watching how veteran physicians do examinations differently, such as how they operate the endoscope during cannulation.

■ Measures to Reduce X-Ray Dose at our Hospital

At Kyoto Katsura Hospital, I think the level of awareness about protecting medical personnel from radiation exposure is relatively high. Medical personnel wear not only a full protective cover that also covers the back, but they also wear a neck guard and protective eyewear. X-ray dose levels are measured using a glass dosimeter monitor worn on the chest (or abdomen) and a glass dosimeter for the eye lens worn on the head (or neck). Nursing personnel also wear the same protective gear. Also, due to requests from physicians and others, a protective cover was installed over the main unit to protect personnel from exposure to scattered X-rays emitted from the X-ray tube.

The fluoroscopy image processing engine in the G4 system currently used for ERCP includes functionality for reducing X-ray dose from fluoroscopy, of which we mainly use the (1) normal dose, (2) L2 (low-dose 2), and (3) L3 (low-dose 3) modes. A pulse rate of 15 frames is used for all three modes, but a 7.5 frame fluoroscopy mode is also available. (See Fig 1.)

If an appointed technologist is assigned, fluoroscopy is started in the L3 mode and then switched to L2 if visibility in fluoroscopic images is inadequate, due to the patient body characteristics or other factors. We are also mindful of operating the collimator properly to avoid irradiating unnecessary areas with X-rays. The virtual collimator is especially helpful for that purpose. The ability to display the collimation status in the last hold fluoroscopic image ensures radiation is collimated to the optimal position when fluoroscopy is started.

Just before examinations, we have a briefing from the physician about the patient's symptoms and the examination or procedures to be performed. That helps to anticipate how the examination or other procedures will be conducted to better determine the timing of fluoroscopy or radiography.

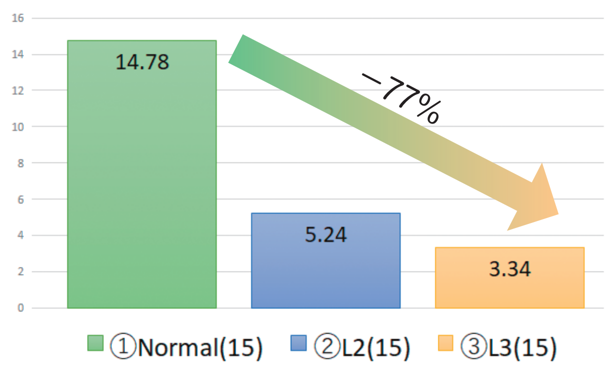


Fig. 1 Dose Level for Each Fluoroscopy Mode (AKR in mGy/min)

In general, fluoroscopy is performed at the timing specified by the physician. Because technologists remain in the control room waiting for the physician's instructions, the timing tends to be delayed. Therefore, technologists try to act as though they are also present in the examination room. Because the technologists perform their job full-time, they eventually can anticipate the procedure habits of the physicians. For example, they can generally anticipate the timing for switching fluoroscopy ON or OFF without being told. During examination, technologists watch three things—the fluoroscopy image, the endoscopy image, and where the physician is looking. That makes it easy to imagine the timing for switching fluoroscopy ON/OFF based on the progress status in the endoscopy image and enables fluoroscopy to be switched OFF when the physician looks away from the fluoroscopy monitor. This type of coordinated operating style allows the physician to concentrate on the procedure and helps reduce any unnecessary fluoroscopy exposure. It is in these types of situations where having appointed technologists is especially beneficial.

For the reference, this is the data that shows a comparison of total exposure dose levels for actual procedures in the L2 and L3 modes.

<Table> Total Exposure Dose Comparison for Examinations in L2 and L3 Modes

	Fluoroscopy Parameters			Accumulated Fluoroscopy Time	Number of Exposures	Dose Area Product	Total Exposure Dose*
	Pulse Rate	Tube Voltage	Tube Current				
L2	15fps	93kV	4.2mA	10minute 10seconds	16images	323.7μGym^2	65.9mGy
L3	15fps	91kV	2.7mA	10minute 8seconds	16images	225.7μGym^2	58.0mGy

* Total exposure dose was measured in terms of the air kerma rate at a point 30 cm above the tabletop, in accordance with IEC regulations.

■ Key Considerations during Examination

When fluoroscopy is performed in the beginning of examination, the angle and position of the fluoroscopy view is decided based on the predicted path of the target duct (biliary or pancreatic duct). Then at the stage the guide wire is inserted, fine adjustments are made to ensure both the wire tip and end of the endoscope camera are visible within the field of view. If insertion is difficult using the default 12-inch field of view, the technologist can suggest magnifying the view by switching to the 6-inch view and then switching back to the 12-inch view after insertion. If the scope of the endoscope overlaps with the region of interest, then X-rays can be projected at an oblique angle to ensure the region of interest can be properly observed.

■ Evaluation of the L3 Ultra-Low Dose Mode in SUREengine FAST

My first impression was "Wow, this is amazing!"

Even though the new low-dose mode (L3) reduces dose level about 35 % lower than the previous low-dose mode (L2), it results in almost no noticeable degradation of image quality. Contrast and graininess can be slightly worse for large patients, but I did not notice any appreciable decrease in guide wire visibility or contrast with respect to contrast agent, for example. The L3 mode may have some minor issues that need ironing out, but it is more than adequate for regular ERCP use. Given that it can decrease exposure dose levels by 75 % compared to the normal mode, I think it is very effective.

Advice to Physicians Considering a SONIALVISION G4 System

Since dose management is the job of the technologist, we think that it is very important to provide the best possible conditions for medical personnel and patients. We think the SUREengine FAST functionality for low-dose fluoroscopy deserves high marks for its ability to reduce exposure dose levels while maintaining a high level of image quality. Furthermore, the SONIALVISION G4 also offers very high performance levels.

RAD

MobileDaRt Evolution MX8 Version Brought Substantial Change to our Radiography Workflow

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1. Introduction

Toho University Ohashi Medical Center was established in 1964 in Ohashi, Meguro-ku of Tokyo as the second hospital affiliated with Toho University. During its subsequent development and reconstruction, the hospital has undertaken its role as a university hospital while also providing medical care for the local community of the southwestern ward medical region of Tokyo (comprising Meguro-ku, Setagaya-ku, and Shibuya-ku) as a designated secondary emergency care hospital. The hospital building aged substantially and lost much of its ability to resist earthquakes over the 50-year period since first opening, and on June 20, 2018, the hospital was reopened on a new, adjacent site, where it is currently located and boasts a seven-story building, 319 hospital beds, and 24 clinical departments **(Fig. 1)**. The new hospital site was designed according to the concept of “a hospital surrounded by water and green,” and is surrounded by numerous trees, water features that make use of changes in elevation such as waterfalls, fountains and ponds, and a park. The new site has more than doubled the site area of the former hospital, increasing both the size of the building and the amount of floor space. By contrast, the number of hospital beds was reduced by 120 to 130 beds compared to the old location, to a total of 319 beds. This increased the floor space allocated to each bed to provide a more relaxed environment for the patient. Building on the underlying idea of “medical care provision with a kind and gentle heart,” in its new location the hospital has placed a strong focus on coordinating with local medical institutions, and worked hard to provide better patient-focused medical care as a city emergency hospital.

Fig.1 External Hospital View

2. Background of Adoption

Toho University Ohashi Medical Center introduced a Hospital Information System (HIS) and Radiology Information System (RIS) in 2001, moved to filmless radiography in 2009, and introduced electronic medical records in 2011.
In the old hospital building, mobile (ward round) radiography was performed with three mobile X-ray systems, including a MobileArt system (Shimadzu). Computed radiography (CR) was used in all X-ray systems, including mobile X-ray systems, though the hospital did start to use a flat panel detector (single detector, 14 by 17 inch) for mobile radiography. The flat panel detector (FPD) was used by attaching a digital radiography (DR) console to the mobile X-ray system. As the old hospital building lacked a wireless LAN environment, and wired LAN ports were only installed in the Department of Radiology, order information and images could only be received and sent by physically removing the laptop PC from the mobile X-ray system. The difference in image quality between CR images and FPD images also lead to the FPD being mainly used for radiography of bones in the operating room. Nevertheless, the FPD allowed us to view images on-site after radiography, which increased work efficiency and was much appreciated by physicians. However, RIS terminals for mobile radiography and the cables used to connect to PACS were only present in general radiography rooms, which necessitated traffic between the bedside and the general radiography room whenever an emergency order was submitted. The DR console monitor for viewing images was also just 12.1 inches, which made it difficult to determine

implant status or confirm a catheter tip position without magnifying the image.

Alongside the transfer to a new hospital site, the decision was made to obtain DR systems and convert all X-ray systems to FPDs, including all mobile X-ray systems. Equipment for the new hospital building was chosen on the assumption that DR systems would be mounted on X-ray systems, and the hospital environment was re-evaluated for mobile radiography, and the following requests concerning the in-hospital environment and related matters were conceived. To minimize movement of mobile X-ray systems, include a storage space with power outlet and wired LAN port on-site where mobile radiography rounds occur. To reduce system transportation times and increase the throughput of radiological technologists, and thereby improve work efficiency, install a wireless LAN environment on-site where radiography rounds occur to allow receipt of order information and direct transfer of acquired images. Demands for the X-ray systems were as follows: (1) The ability to perform radiography while the X-ray system is a good distance from the patient's bed, and an X-ray tube with a wide angle of adjustment to accommodate positioning in any situation. (2) A system that can be operated safely even by radiological technologists of smaller stature, that allows good visibility both in front of and under the system. (3) A monitor that allows easy viewing of acquired images. (4) The ability to connect to RIS and PACS through a wireless LAN. In accordance with these demands, an initial decision was made to obtain all DR systems from FUJIFILM, and to acquire five mobile X-ray systems equipped with FUJIFILM DR systems. Considering the specific features of each manufacturer and the characteristics of the hospital environment, this initial plan to procure equipment of a single manufacturer and model was altered, and three different system models were obtained from three different manufacturers. Of these systems, two were Shimadzu's MobileDaRt Evolution MX8 Version **(Fig. 2)**.

Fig.2 MobileDaRt Evolution MX8 Version

3. Environment and Operation

The hospital is located in a seven-story building with an emergency unit, an operating room, and an intensive care unit (ICU, HCU, and SCU) on the third floor, and general wards located on the fourth through seventh floors. A single X-ray system was allocated to each of the emergency unit, the operating room, and the intensive care unit, another system was assigned to floors four and five, and another to floors six and seven. A storage area was also created for each system with a power outlet and wired LAN port. IBM was chosen to supply the ordering system and electronic medical records, FUJIFILM to supply PACS, and INFOCOM to supply the RIS and image quality assurance system. A wireless LAN environment was also installed in the hospital, allowing for wireless receipt of order information and wireless transmission of images.

At first, the two MobileDaRt Evolution MX8 Version systems were allocated to general wards, but currently these systems are allocated to the emergency unit and the intensive care unit. There, they are equipped with a 14 × 17 inch FPD. Our operational workflow is as follows. (1) Check order information on an RIS terminal in the general radiography control room, and accept the order. (2) Collect a spare battery pack and FPD unit, which are stored separate to the mobile X-ray system, and take them to the X-ray system storage space. (3) Turn on the X-ray system, transport it to where radiography will be performed, and receive order information over wireless LAN from the RIS. (4) Select the relevant patient from the list displayed on the MobileDaRt Evolution MX8 Version monitor, confirm the patient's name, then use the barcode reader to verify identity by reading the patient's wrist band. After reconfirming the order information, radiography commences. (5) Once radiography has ended, the images are checked, then sent automatically to the image quality assurance system over wireless LAN. (6) The person in charge of image quality assurance checks the images, then sends them to the image storage server.

4. Experience Using MobileDaRt Evolution MX8 Version

4.1 External Design and Maneuverability

The MobileDaRt Evolution MX8 Version system does not have the somewhat oppressive, boxy look of previous X-ray systems, but instead has a gentler, rounded design. The system appears bulky due to this rounded design, but is actually just 56 cm wide and can easily be maneuvered into small hospital rooms. The system also does not vibrate and is silent during transportation, so we no longer worry about noises made by the mobile X-ray system when transporting it through hospital wards at night.

4.2 Telescopic Support Column

A major feature of MobileDaRt Evolution MX8 Version is its telescopic X-ray tube support column. The MobileArt system previously used in the old hospital building was equipped with a 178 cm height column, which impeded vision in front of the system and necessitated caution when transporting the system. When retracted for transportation, the top of the MobileDaRt Evolution MX8 Version telescopic support column is just 127 cm high, and the top of the X-ray tube is just 124 cm high. This gives radiological technologists who are small in stature a good view in front of the system, making transportation easier. This design feature has been particularly well-received by our female radiological technologists. The stowed height of the system is around 20 to 30 cm lower than other three models (Fig. 3). During radiography, the tube focal distance from the floor can be set between 68 cm and 202.5 cm. Hospital beds have tended to increase in height in recent years, and when using MobileArt in the operating room in the old hospital building, a 14 × 17 inch irradiation field was only just usable with the X-ray tube adjusted to its maximum focal distance from the floor, a situation that required caution during abdominal radiography. With the new systems, a maximum focal distance of more than 200 cm provides us distance to spare during positioning.

Fig.3-1 During Transportation

Fig.3-2 Visibility in Front of System

4.3 Monitor

Another major feature of MobileDaRt Evolution MX8 Version is its 19 inch touch panel monitor (Fig. 4). As mentioned earlier, the DR console used in the old hospital building was equipped with a 12.1 inch touch panel monitor, which could only display small images and often required image magnification to pass judgment. Control buttons also appeared small on the monitor and were not particularly easy to operate. However, a larger monitor now allows for images to be checked without the need for image magnification, and the increased control button size also makes them easier to operate, thereby improving work efficiency. The monitor used on MobileDaRt Evolution MX8 Version is also much larger and easier to use than the other three models of mobile X-ray system used in the new hospital building.

Fig.4 19-Inch Touch Panel Monitor

4.4 DR System Startup Time

When the new hospital building was first opened, MobileDaRt Evolution MX8 Version systems were allocated for use on general wards, but are now being used in the emergency unit and the intensive care unit. This change was made based on the two-minute startup time of the DR system, which is shorter than the other models of mobile X-ray system. In the emergency unit and the intensive care unit, where radiography is often performed in emergency situations and shorter radiography times are preferred, a long startup time can be a major source of stress on site. We hope that startup times can be even shorter in the future.

4.5 Collimator

When positioning for radiography, the main unit is placed at the patient's bedside. The only arm lock release buttons on the MobileArt system used in the old hospital building were located on the collimator control handle. In small hospital rooms with limited bedside space, this single button location caused difficulty for radiological technologists who were smaller in stature when positioning the collimator in front of the patient. However, MobileDaRt Evolution MX8 Version has “All Free” buttons on the upper part of the handle but also on the lower part of the handle (Fig. 5), the middle part of the arm (Fig. 6), and the catch area (Fig. 7). These buttons enable

Fig.5 Lower Handle Button

Fig.6 Arm Central Button

Fig.7 Catch Area Button

one-step positioning all for support column rotation, arm extension, and X-ray tube elevation, and provide the operator with controls on the support column side of the system as well as on the collimator side. Elevation of the X-ray tube is now also controlled from a lower location on the system, which makes control easier.

4.6 Image Processing

On transitioning to FPDs, we also chose to obtain the Virtual Grid option. Virtual Grid is image processing software that improves image contrast that was reduced due to scattered X-rays. Virtual Grid is only currently used for chest and abdominal radiography, but this optional software eliminates the labor associated with attaching/removing physical X-ray grids, and also the right and left differences in image density caused by misalignment of physical grids. Virtual Grid also allows the X-ray dose to be reduced by 30 to 40 % compared to CR radiography. Also it is capable of frequency enhancement processing to help identify catheter tips and check for gauze and other forgotten implements.

4.7 Product Options

At one time, patient misidentification became a problem in the old hospital building. To resolve this problem, in addition to checking patient identification orally, the hospital introduced a system of patient verification. Obtaining oral verification from the patient themselves can often be a challenge during mobile radiography, so a visual system of confirmation was implemented using wrist band barcodes. The new mobile X-ray systems strengthen this verification system, and incorporate wrist band barcode verification into the DR system. Barcode readers have also been made wireless **(Fig. 8)**, which reduces the number of wires and makes the equipment easier to use. This feature is also extremely important from the viewpoint of ensuring medical safety.

Fig.8 Barcode Reader

5. Summary

With the transfer to a new hospital building, all mobile X-ray systems were converted from CR to FPD systems. Just six months have passed since obtaining MobileDaRt Evolution MX8 Version, work throughput has already increased substantially compared to the old hospital building. We no longer need to carry X-ray cassettes back and forth through the hospital. The patient verification system of wristbands and barcode readers also strengthens our measures against patient misidentification and helps to improve medical safety. The MobileDaRt Evolution MX8 Version system includes a variety of thoughtful design details, including the larger display monitor and control buttons, which improve ease of use and have been well-received among department staff. MobileDaRt Evolution MX8 Version was clearly designed from the perspective of the radiological technologist who operates the system, and this perspective has created a system that is also beneficial for patients. We hope Shimadzu will continue to listen to the opinions of us, and will be able to develop X-ray systems that are even safer, easier to operate, and better for the patient.

RAD

Experience Using RADspeed Pro EDGE and its Operation at Sendai Nishitaga Hospital


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1. Hospital Introduction

The Hokkaido/Tohoku block of the National Hospital Organization includes 21 facilities in total, of which 3 facilities are hospitals in Miyagi Prefecture. Sendai Nishitaga Hospital **(Fig. 1)** is one of these facilities, and is situated in a hilly area adjacent to the remains of Aoba Castle in the southwestern part of Sendai City. The hospital is surrounded by vegetation for all four seasons, and provides medical care based on the concept of "good medical care given safely and with devotion" that values the rights of the patient. Sendai Nishitaga Hospital has fourteen medical departments, including a department of neurology that specializes in providing medical care for neuromuscular diseases such as muscular dystrophy and Parkinson's, and a department of orthopedic surgery with specialist facilities for the treatment of spinal diseases that provides treatment for degenerative spine conditions, spinal trauma, idiopathic scoliosis, and rheumatoid arthritis. The hospital strives on a daily basis to provide high quality medical care to its patients, and recently opened Dementia Center in September 2015 and a hospital wing for special medicine **(Fig. 2)** in August 2017. To meet the high expectations regarding X-ray images, our Department of Radiology obtained a RADspeed Pro EDGE (Shimadzu) general radiology system equipped with the latest features. This article gives a brief description of system operation and how the system is used at our hospital.


Fig.1 Exterior of Sendai Nishitaga Hospital

2. System Outline

RADspeed Pro EDGE is a general radiology system capable of performing auto-stitching radiography, dual energy subtraction, and tomosynthesis applications.
The layout of the radiography room that holds RADspeed Pro EDGE was designed to avoid confusion with other radiography rooms, with the Bucky stand placed immediately adjacent to the door, the Bucky table at the rear of the room, and a storage rack that holds radiography aids and 10 × 12 inch flat panel detectors (FPDs) on the left when facing to patient entrance to avoid obstructing the passage of the patient. **Fig. 3** shows photographs of the radiography room and control room.
RADspeed Pro EDGE has an auto-positioning function that allows remote control of the X-ray tube, and allows frequently used tube positions to be assigned to buttons on a remote controller **(Fig. 4)**. The Bucky table also has an interlocking function that moves the FPD tray based on the X-ray tube angle, which eliminates concerns over the irradiation field missing the FPD when radiography is performed under oblique projection (as long as radiography is not performed at the end of the table). The system also includes a variety of other useful features that demonstrate it was designed with the operator in mind.
Our hospital performs many surgeries of total spinal and joints of limbs such as posterior lumbar interbody


Fig.2 Special Medicine Wing

Fig.3 Layout of Radiography Room and Control Room
a) Radiography Room
b) Control Room

Fig.4 Remote Controllers for Automatic Positioning for Radiography in Standing and Supine Positions
Controller for Standing Position (Left)
- SID150: Lateral view of thoracic vertebrae, lateral view of lumbar vertebrae, etc.
- SID180: Chest, cervical vertebrae, etc.
- SID200: Auto-stitching radiography
- Park: X-ray tube position when not in use

Controller for Supine Position (Right)
- Home: Anterior view of lumbar vertebrae, etc.
- AXIAL: Axial position of patella, etc.
- Park: X-Ray tube position when not in use

Fig.5 Fender wall for Auto-Stitching Radiography in Standing Position
The FPD moves automatically during radiography, so the fender wall enhances patient safety. Adjustable handrails and a step are also included in consideration of patients with poor lower body function.

fusion or total joint replacement as well as surgeries with screws and hooks such as idiopathic scoliosis. Auto-stitching radiography and tomosynthesis radiography play very important roles at this hospital in examinations used to observe the status of metal implants after surgery. Auto-stitching radiography and tomosynthesis radiography are described below.

3. Auto-Stitching Radiography

3.1 Experience Using Auto-Stitching Radiography

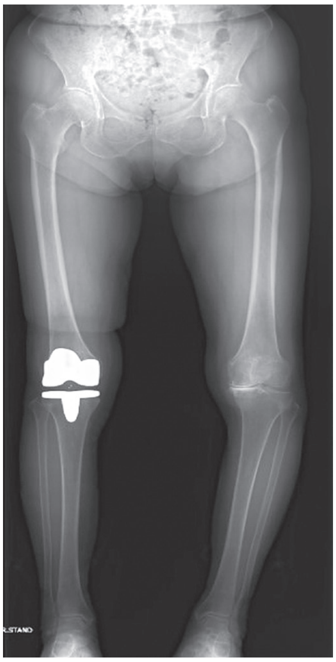
Auto-stitching radiography provides complete adjustability to the demands of the radiography subject, with the ability to choose between typical sizes of irradiation field, between portrait and landscape imaging, and choice over the number of acquisitions (number of sub-divisional images) used. Patients receive double the X-ray dose where overlapping occurs at joints between images, so the area of overlap must be minimized by choosing an appropriate irradiation field size and number of image parts. Despite this, auto-stitching radiography is still quick and simple, and due to its reduced burden on the patient is far more useful than computed radiography (CR).

As for the standing position, the Fender wall **(Fig. 5)** is installed with safety in mind using an FPD that moves automatically, and we take extra care of preventing patient's falls when go up the two steps (10 cm) onto the stand base.

At Sendai Nishitaga Hospital, auto-stitching radiography is mainly used for whole leg radiography under a weight loading state, including cases of rheumatoid arthritis, for full-spine radiography in patients with idiopathic scoliosis, and for femur radiography.

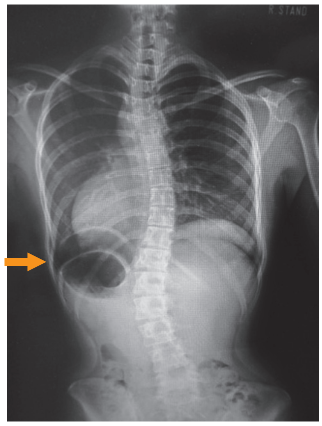
3.2 Whole Leg Radiography

Whole leg radiography was previously performed with the patient in a standing position using two or three imaging plates (IPs) of 14 × 17 inches to acquire an image from the pelvis to the ankle. The patient must be positioned with their patellas in median direction, though many patients with genu varum or genu valgum prevented the greater trochanter of femur or lateral malleolus from appearing in the image. In those cases, radiography was performed on each leg individually. Auto-stitching radiography can provide the whole leg image in three 17 × 14 inch or 17 × 17 inch size field of views. The 17 inch width allows for radiography of both legs in a single acquisition for patients who would previously have required separate acquisitions for each leg **(Fig. 6a)**. Since this radiography is performed for patients with impaired function in their lower bodies, careful attention is given to preventing falls throughout the examination process.



a) Whole Leg Radiography

b) Full-Spine Radiography
Accurate breath hold



c) Full-Spine Radiography
Inaccurate breath hold

Fig.6 Whole Leg and Total-Spine Radiographs Obtained by Auto-Stitching Radiography
a) Whole Leg Radiography Patient with genu valgum. Using a 17 inch wide FOV allows both legs to be shown in a single image, which assists with determining the status of the lower body compared to when separate images of each leg are used.
b) Full-Spine Radiography An accurate breath hold eliminates artifacts in the overlapping part of the image.
c) Full-Spine Radiography The gastric bubble and free-air-like artifact appear in lower lung field (➡) due to an inaccurate breath hold.

3.3 Full-Spine Radiography

Idiopathic scoliosis most commonly occurs in young people 20 years or under. On some days, our hospital may perform full-spine radiography on many tens of people, including examinations of new cases and follow up examinations. Radiography image of idiopathic scoliosis must include the spine from the Th1 vertebra to the S1 vertebra to measure the angle between the spine and pelvis. This was previously achieved by using two IPs of 14 × 17 inches. In some cases, the patient was made to lie supine on the hard IP, and substantial time was required between positioning to viewing the acquired image. Now with RADspeed Pro EDGE, radiography can be performed simply by choosing the irradiation field size and number of acquisition times to minimize overlap but include the target area, then pressing the exposure switch. The resulting image can even be viewed immediately on the system monitor. RADspeed Pro EDGE has resulted in major changes to our workflow compared to before its adoption, and has dramatically improved our examination efficiency. We also previously used the minimum X-ray dose required to visualize vertebral disks due to the patients being young people, but using highly sensitive CsI-type FPDs that produce high quality images at low X-ray doses now allows us to further reduce the X-ray dose by 20%.
One area of difficulty with this type of radiography is the need to vertically move the FPD and perform two exposures, which requires careful attention to body movement and breath holding during radiography (Fig. 6 b, c). Auto-stitching radiography is also difficult to perform in patients with mental disabilities or in severely mentally and physically handicapped patients (children), and in these case we continue to perform radiography using an IP with a single exposure.

3.4 Femur Radiography (14 × 17 Inch-Sized Femur Radiograph)

Femur radiography uses a 14 × 17 inch IP and requires the patient be positioned with their femur at an angle in the image. Many radiological technologists found it challenging to acquire an image of the femur, the longest bone in the body, within a single radiograph. The burden of this examination on the patient is also high, as they are required to lie on top of a hard X-ray grid. Auto-stitching radiography, however does not require the patient lie on a hard X-ray grid, and is also able to visualize the long femur bone with a single image.

4. Tomosynthesis Radiography

4.1 Experience Using Tomosynthesis Radiography

Tomosynthesis radiography requires patient positioning to reduce body movement, a geometric layer height determined by the X-ray tube, and a layer height defined by reconstruction software on the operation console before acquisition. A major error in layer height in particular will lead to image blurring, so the height must be entered with due care. The system can acquire a maximum of 60 images in 12 seconds, so both breath holding and reduction of body movement require due attention. After radiography is complete, raw images are transmitted to a dedicated reconstruction workstation, where reconstruction is executed automatically according to a preset parameters. Reconstruction can be performed quickly by the filtered back projection (FBP) method, which takes around just 10 seconds (for 60 images).

Reconstruction may then be repeated manually using Shimadzu's proprietary T-smart (tomosynthesis-Shimadzu metal artifact reduction technology) reconstruction method, which uses iterative reconstruction (IR). T-smart reduces metal artifacts and allows observation of bone trabeculae around metal implants.

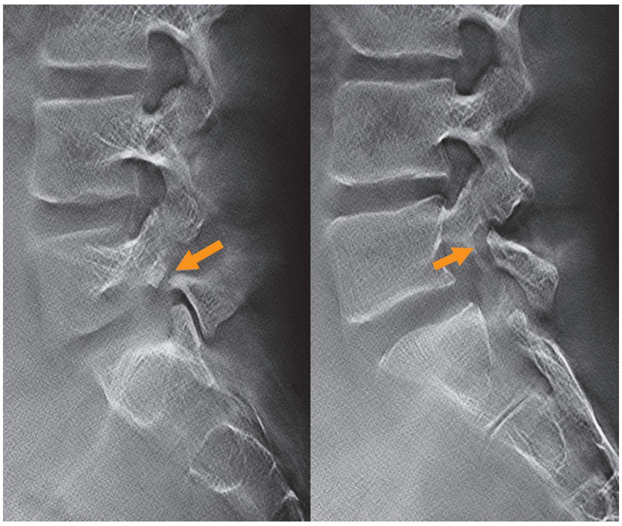
T-smart with eight iterations requires around 2 minutes to complete, and is dramatically more useful for patients with metal implants than the prior FBP method.

At this hospital, the FBP method is used during diagnosis of lumbar vertebral dysplasia in children and lumbar spondylolysis in teenagers when high-resolution and highly detailed tomographic images are needed at a reduced X-ray dose, and T-smart is used when metal implants are present in extremities and vertebral bodies to reduce metal artifacts and evaluate bone trabeculae around the metal. **Fig. 7** shows cases of lumbar spondylolysis and lumbar vertebral dysplasia reconstructed by the FBP method.

4.2 T-smart Method

T-smart method uses an algorithm that combines metal extraction and reconstruction by iterative reconstruction in cases with artificial joints and other metal implants, substantially reduces metal artifacts, and shows the fine trabecular structure around the metal implant.

Parameters used by this reconstruction method are the target region, and the type and amount of metal in the implant. Metal type must be chosen based on the target region, such as "L-sp lateral metal" for the lateral shot of lumbar vertebrae after posterior lumbar interbody fusion (PLIF) and "Metal THA" for total hip arthroplasty (THA). Good reconstruction also requires choosing the appropriate size of metal implant, such as S, M or L. We investigated the types and sizes of metal implant present in past cases that



a) Tomosynthesis Radiography
(Spondylolysis of Fifth Lumbar Vertebra)

b) Tomosynthesis Radiography
(Cervical Vertebral Dysplasia)

c) Tomosynthesis Radiography
(Lumbar Vertebral Dysplasia)

Fig.7 Tomosynthesis Radiographs (FBP Reconstruction)
a) Spondylolysis of Fifth Lumbar Vertebra
Separation of left and right pars interarticularis in same person. The fracture line on a radiograph shows only the right side separation, on the other hands tomosynthesis radiography revealed also a left side separation.
b) Cervical Vertebral Dysplasia
Irregular vertebra with C5 and C6 the only movable cervical vertebra. Tomosynthesis radiography revealed that C4 was a butterfly vertebra.
c) Lumbar Vertebral Dysplasia
Diagnosed with an L4 hemivertebra. Tomosynthesis images showed the condition was indicated for surgery, and allowed the actual size of the hemivertebra to be measured.

underwent tomosynthesis radiography at this hospital, and showed an inappropriate choice of metal type could cause metal artifacts to appear and obscure bone trabeculae. Choosing a size larger than the appropriate size also obscured bone trabeculae around the metal, and choosing a smaller size caused metal artifacts. Consequently, choosing the appropriate metal type and size is extremely important for T-smart. Fig. 8 shows T-smart reconstruction images for various cases with metal implants. These images were reconstructed using the appropriate parameters, and show reduced metal artifacts in images that allow evaluation of looseness around the metal and clearly show bone trabeculae.


a) THA A-P Image


b) TKA A-P Image


c) Femur A-P Image


d) PLIF Lateral Image

Fig.8 Various Cases with Metal Implants (T-smart Reconstruction)
a) THA A-P Image
For assessment of bone trabeculae around the femoral stem and to evaluate for looseness.
Using T-smart and displaying Oblique Reslice images allowed an evaluation of the femoral stem.
b) TKA A-P Image
Artifacts around the metal are reduced, and looseness is observed on the lower leg side of the implant (➡).
Cement and bone trabeculae around the metal implant are also shown clearly.
c) Femur A-P Image
After open femoral fracture surgery. For evaluation of bone fusion to determine whether to remove the plate. Only partial bone fusion has taken place.
d) PLIF Lateral Image
The rods are fully implanted in the vertebral arch of both L5 and S1, and based on the bone trabeculae around the rods there seems to be no looseness.

4.3 Oblique Reslice Image Function

The workstation not only performs image reconstruction, but also has an Oblique Reslice Image display function capable of tilting the image to display the median plane. Due to positioning constraints, a cross-section of the target region will not necessarily be parallel to the tabletop, so the Oblique Reslice Image function can generate cross-section images at an angle of up to ±20 degrees in a longitudinal and lateral direction.
Though care is taken with patient positioning after THA to ensure the femoral stem is parallel to the tabletop, in many cases a parallel relationship is not achieved and the stem cannot be displayed in a single cross-section image. Physicians have reported that this creates difficulties when evaluating the stem and bone trabeculae around the stem. However, using the Oblique Reslice Image function on the workstation after radiography creates a cross-sectional image of the stem that helps improve the quality of medical examinations.

5. Summary

This article briefly describes how the RADspeed Pro EDGE general radiography system is used to perform auto-stitching radiography and tomosynthesis radiography, and how the system is used at our hospital. We have experienced may challenges over the years when performing radiography on subjects with metal implants, and this system has dramatically improved the efficiency and quality of our examinations and reduced the burden of examinations both for patients and radiological technologists. We look forward to examining an increasing number of clinical cases with this system and further demonstrating its clinical utility.

This article describes the poster presentation made about Shimadzu tomosynthesis.

Reliability of Diagnosis of Acetabular Dysplasia with Tomosynthesis

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1. Introduction

Acetabular dysplasia that concentrates the joint contact pressure distribution can result in cartilage degeneration. An accurate evaluation of acetabular coverage is important in cases of acetabular dysplasia, as diagnosis and treatment methods differ depending on the degree of coverage. However, diagnostic criteria for acetabular dysplasia can depend on the radiography method and limb position used for evaluation, and are not always equivalent.[1),2)] Tomosynthesis is a radiographic technique that can be used with a variety of body and limb positions including upright or supine and that produces multiple tomographic images from a single acquisition, which therefore allows a more detailed evaluation of the bone trabecular structure[3)] **(Fig. 1)**.

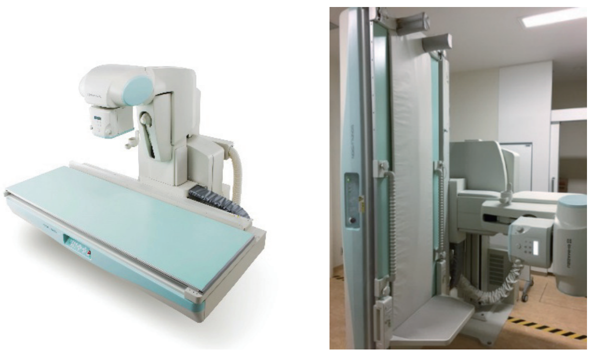

Fig.1 Shimadzu SONIALVISION G4 R/F System
This system can perform tomosynthesis with the patient upright position.

2. Objective

The objective of this study was to compare the reliability of diagnosing acetabular dysplasia when using radiography images (Xp) and tomosynthesis images.

3. Subjects and Methods

This study investigated 54 hip joints of 27 patients diagnosed with acetabular dysplasia following examination at this hospital between December 2016 and September 2017, and analyzed 49 hip joints with a center-edge angle (CEA) of under 25° according to radiography images. Subjects included 3 males and 24 females with an overall mean age of 42.6 years (20–56). Five hip joints with a CEA of ≧ 25° on radiography images were excluded from analysis. Other exclusion criteria were a KL classification of grade 2 or higher osteoarthritis, a history of hip joint surgery, and rheumatoid arthritis or any other inflammatory disorder, though no subjects met these criteria.

The body and leg position used for radiography were upright and 15° internal rotation, respectively. Radiography images of the front view of the hip joint were obtained on a general radiography system, and tomosynthesis images were obtained with Shimadzu SONIALVISION G4. CEA,Sharp angle (SA), and Acetabular roof obliquity (ARO) are angles used to evaluate acetabular dysplasia, and were the

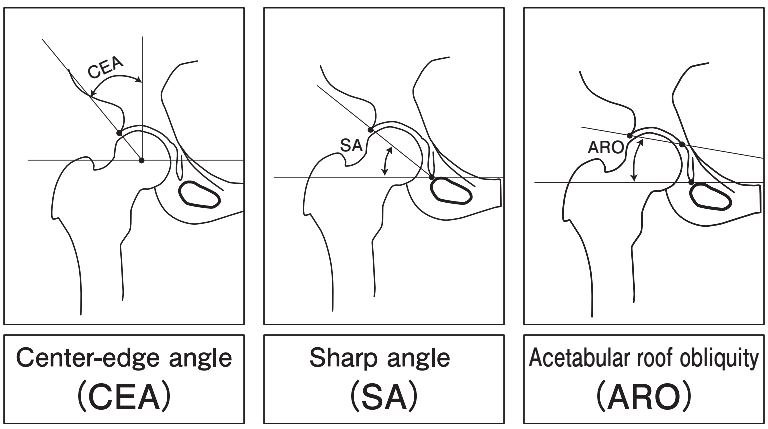

Fig.2 Angles Used to Evaluate Acetabular Dysplasia (CEA, SA and ARO)[2)]

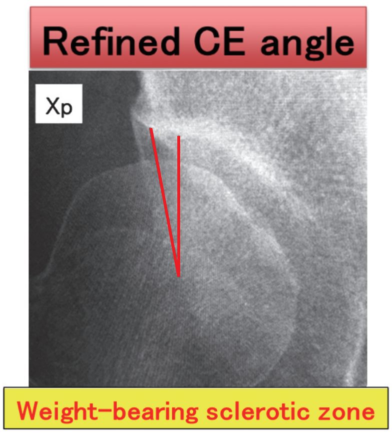

Fig.3 Refined CEA of Ogata et al.[5)]

parameters investigated in this study[2] **(Fig. 2)**. These angles were measured by determining the weight-bearing sclerotic zone then measuring the Refined CEA according to Ogata et al. [5] **(Fig. 3)**.
Statistical analysis was performed with JMP software package version 11.2 (SAS Institute, Cary, NC, USA). A paired t-test was used to compare radiography images and tomosynthesis images, and intra-rater and inter-rater concordance rates (Interclass Correlation Coefficient [ICC]) were calculated. $p < 0.05$ was considered significant.

4. Results

The mean and standard deviation statistics for CEA, SA and ARO measured using radiography images and tomosynthesis images are shown in **Table 1**. Tomosynthesis CEA was significantly larger, and tomosynthesis SA was significantly smaller than measured using radiography. The intra-rater concordance and inter-rater concordance rates of the three angles are also shown in **Table 2**.

Table.1 CEA, SA and ARO measured using Radiography and Tomosynthesis

Comparison of Xp and Tomosynthesis

	Xp	Tomo	Difference (Xp−Tomo)	P value
CEA	13.2 (6.3)	16.8 (7.1)	−3.6 (3.6)	0.0085
SA	47.1 (3.4)	45.7 (3.5)	1.4 (1.5)	0.047
ARO	16.2 (6.0)	15.6 (6.6)	0.59 (3.3)	0.64

Mean
(Standard deviation)

Table.2 Intra-Rater and Inter-Rater Concordance Rates for CEA, SA and ARO[4]

Intra-rater concordance rates

	Xp (ICC)	Tomo (ICC)
CEA	0.90	0.87
SA	0.74	0.79
ARO	0.87	0.87

Inter-rater concordance rates

	Xp (ICC)	Tomo (ICC)
CEA	0.87	0.86
SA	0.91	0.82
ARO	0.87	0.92

ICC

0.00−0.20, slight
0.21−0.40, fair
0.41−0.60, moderate
0.61−0.80, substantial
0.81−1.00, almost perfect

5. Discussion

A comparison of this study and a previous report on radiography methods used for diagnostic imaging of acetabular dysplasia is shown in **Fig. 4**. Chadayammuri et al. compared CEA obtained by radiography and CT images. and reported that CT images showed significantly larger than radiography in Hip dysplasia (acetabular dysplasia) and Cam-type FAI(FemoroacetAbular Impingement). This difference arose because Refined CEA of Ogata et al. was measured by radiography (supine) and Classic CEA of Wiberg was measured by CT images (supine).[2),6)]
In the meantime, tomosynthesis can be used to acquire tomographic images in an upright position,and tomosynthesis allows for the detailed evaluation of the load plane of the acetabular cover. The reason for the significant difference in CEA and SA observed in this study is considered to be that tomosynthesis allowed a more accurate measurement of the lateral acetabular rim, which is the load plane of the acetabulum, compared to radiography.
The limitations of this study are that no investigation was performed into a relationship with symptoms, and no comparison was made with CT, MRI or other image-based evaluation methods.

6. Conclusion

Tomosynthesis allowed a more detailed diagnosis of acetabular dysplasia in an upright position compared to radiography. Tomosynthesis can potentially be applied in diagnostic imaging of acetabular dysplasia to help in determining a treatment plan.

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6) Wiberg et al. Acta Chir Scand 1939

Chadayammuri et al(2015)		Xp	CT	Difference (Xp−CT)	P value
Hip dysplasia	CEA	17.5 (1.9)	22.6 (4.0)	−4.9	<0.001
Cam-type FAI with concomitant hip dysplasia	CEA	17.3 (4.0)	22.8 (3.2)	−5.5	0.011

Xp: Refined CEA | CT: Classic CEA

Weight-bearing sclerotic zone not being measured.
Limb position for radiography:
evaluated supine in non-weight-bearing position

This study		Xp	Tomo	Difference (Xp−Tomo)	P value
Hip dysplasia	CEA	13.2 (6.3)	16.8 (7.1)	−3.6 (3.6)	0.0085

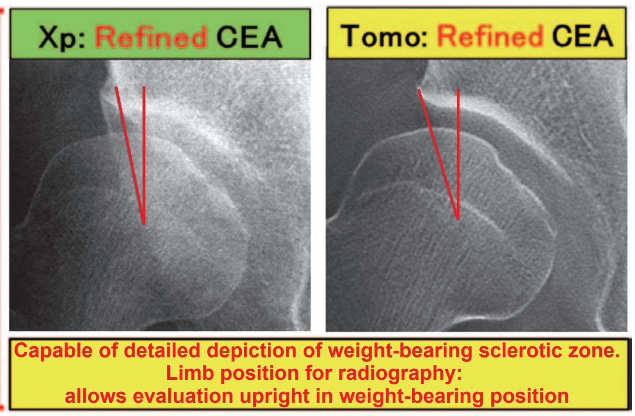

Fig.4 Comparison of this Study and a Previous Report on Radiography Methods for Diagnostic Imaging of Acetabular Dysplasia[2),6)]

This article describes the poster presentation made about Shimadzu tomosynthesis.

Validity of tomosynthesis for evaluation of bone graft integration in anterior cruciate ligament reconstruction using bone-patellar tendon-bone graft —Comparison with CT images—

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1. Background

The evaluation of bone graft integration after anterior cruciate ligament (ACL) reconstruction using a bone-patellar tendon-bone (BTB) graft is important for assessment of postoperative treatment. Standard radiography is often used to evaluate bone integration, though the sensitivity and specificity of this approach is low.[1)] Computed tomography (CT) is highly sensitive and specific, and is considered effective compared to radiography.[2)] However, CT has the disadvantages of being high in cost and causing high radiation exposure.[3)]

Tomosynthesis (TS) is a technology that produces a large volume of data by obtaining several tens of tomography images in a single acquisition, which is lower cost and causes less dose than CT.[4)] Based on a literature search by the authors, no studies have yet used this technology to evaluate bone graft integration after ACL reconstruction surgery.

2. Objective

To clarify the diagnostic value of TS in the bone graft integration evaluation of bone graft after ACL reconstruction using a BTB graft.

3. Subjects and Methods

This study included 24 cases who underwent their first ACL reconstruction using a BTB graft between January and June 2017.

Surgical method:

Anatomical rectangular bone tunnel ACL reconstruction using a BTB graft.[5)] The graft was secured at the femoral side with an Endobutton, and secured at the tibial side with a Double Spike Plate (DSP) **(Fig. 1)**.

Image evaluation:

Radiography was performed 3 months after surgery simultaneously by CT and TS using a Shimadzu R/F system, and coronal plane and sagittal plane sections of 2 mm thickness were reconstructed **(Fig. 2)**.

Bone integration in the femur and tibia was evaluated by the coronal plane and sagittal plain. Bone integration was defined as partial trabecular continuity between the bone graft and bone tunnel **(Fig. 3)**.

Of the image slices that showed a bone graft, the proportion of images that showed bone integration

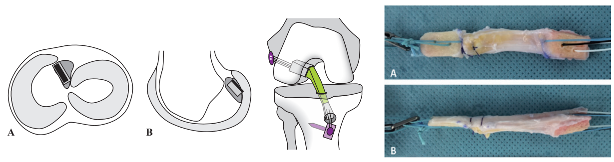


Fig.1 Anatomical Rectangular Bone Tunnel ACL Reconstruction Using BTB Graft

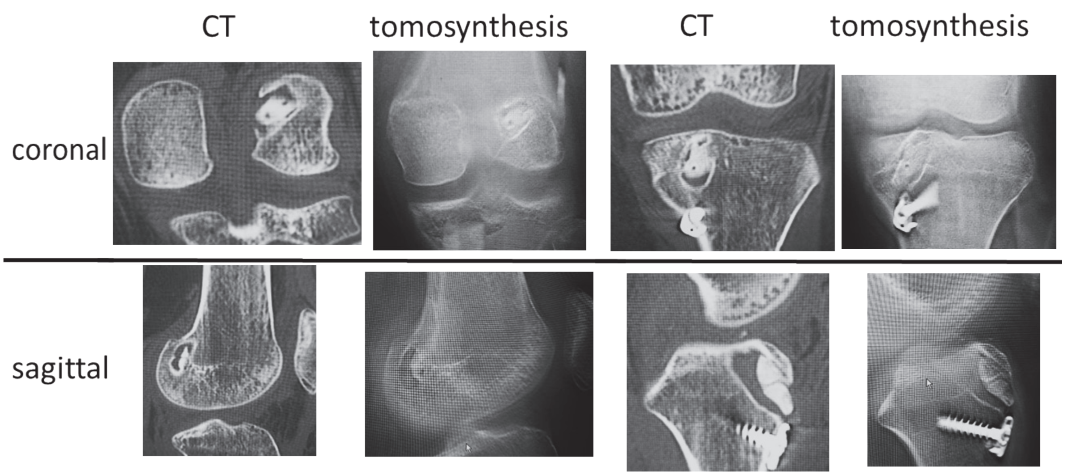


Fig.2 Comparison of CT and TS (in Coronal Plane and Sagittal Plane for Femur and Tibia)

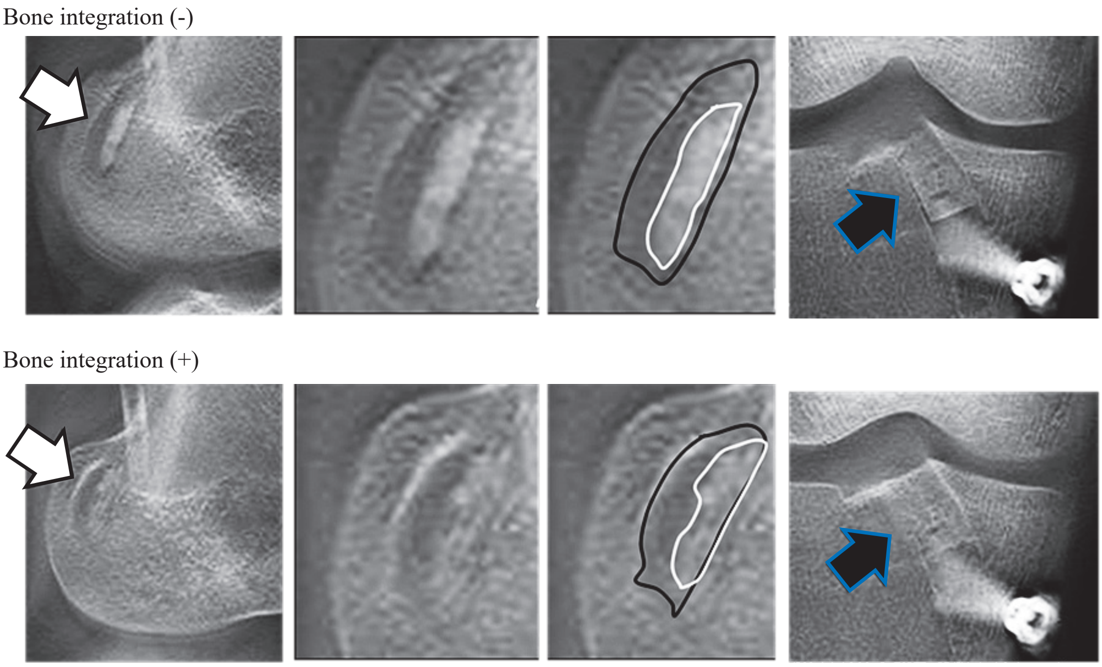


Fig.3 Non-Bone Integration (Top) and Bone Integration (Bottom) Shown by TS

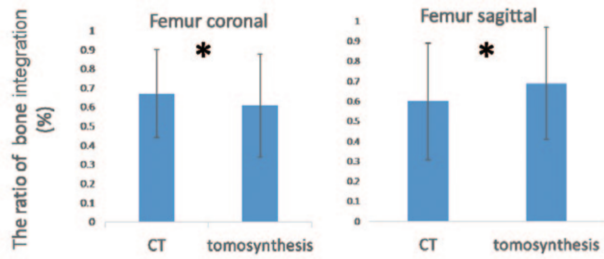
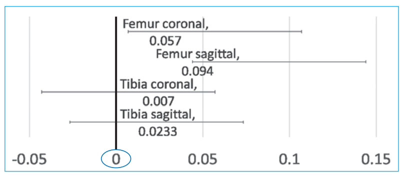


Fig.4 Comparison of Bone Integration Evaluated Using CT and TS (in Coronal Plane and Sagittal Plane of Femur)



ICC (Femur)

	coronal	sagittal
CT	0.81	0.92
tomosynthesis	0.82	0.76

ICC (Tibia)

	coronal	sagittal
CT	0.74	0.96
tomosynthesis	0.73	0.89

Fig.5 Confidence Interval of Difference between CT and TS (Left), and Inter-Rater Difference (ICC) (Right)

was determined (number of slices showing bone integration/number of slices showing a bone graft), and this proportion was compared at the femur and tibia sites for CT and TS. All images were evaluated by two specialists of orthopedic surgery. The proportion of images showing bone integration was compared at each part, and the confidence interval for the difference between CT and TS was determined using the mean of values obtained from the two specialists. The inter-rater difference (intraclass correlation coefficient [ICC]) was also investigated.

4. Results

CT and TS of 24 cases were investigated retrospectively. Comparing the proportion of CT and TS images showing bone integration revealed CT and TS confidence intervals overlapped when examining coronal and sagittal plane images of the tibia. There was a significant difference between CT and TS for the femur, but the difference was small **(Fig. 4)**, and assuming a non-inferiority margin of 0.1 (10 % examination error) caused the CT and TS confidence intervals to overlap and the results to be equivalent. ICC exceeded 0.7 when using either method of examination **(Fig. 5)**.

5. Discussion

After assuming a non-inferiority margin of 0.1 (10 % examination error), the results suggested that TS was not inferior to CT in the evaluation of bone integration after ACL reconstruction surgery using a BTB graft. The advantages of TS are (1) short examination times, (2) low cost of examination compared to CT, (3) few metal artifacts,[6] (4) low dose compared to CT,[7] and (5) also low cost in terms of hospital facilities.
The limitations of this study were the (1) small number of cases, and (2) no established method for evaluating bone integration using TS. We plan to continue this study and increase the number of cases to a suitable number for this investigation.

TS may be considered a useful diagnostic tool for the evaluation of bone integration after ACL reconstruction with a BTB graft.

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Change in Reduced Position after Locking Plate Surgery for Intra-Articular Fracture of the Distal Radius
—Evaluation by Tomosynthesis—

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1. Background

Because the angle-retaining characteristics of locking plates provide good retention of fractures in a reduced position, they are said to be especially effective in treating intra-articular fractures. However, previous reports only involved measurements using radiography (Xp) and there are no reports of evaluating whether joint surfaces were retained in a reduced position after surgery[1), 2), 3), 4)]. CT is excellent for evaluating inside joints[5)], but an alternative examination method is desirable because CT requires higher X-ray dose levels. Tomosynthesis (TS) involves acquiring a few dozen cross-sectional images per acquisition, which requires lower X-ray dose levels than CT.

2. Purpose

To evaluate corrective loss of intra-articular dislocation by TS after locking plate surgery for intra-articular fractures.

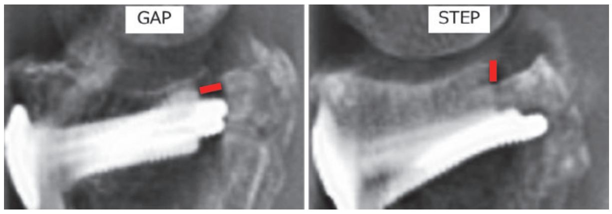
3. Applicable Cases and Methods

In 68 of the 89 cases involving locking plate surgeries (one DVR-1, 18 Acu-Loc 2 proximal, 35 Acu-Loc 2 distal, and 14 Variax plates) for intra-articular fractures performed at the hospital between May 2015 and September 2017, follow-up observations were made using TS and Xp one day after the surgery (on average 1.2 ± 1.3 days, ranging from 0 to 2 days after) and 12 weeks after the surgery (on average 87.0 ± 11.6 days, ranging from 74 to 105 days after). The male to female ratio was 22:46 and the mean age was 62.0, with a standard deviation of ±15.0 (16 to 88).

Excluded cases include one case with repeated surgeries involving multiple fractures and an open fracture, and 20 cases where TS was not performed. The number of required samples was 62[8)] given the clinical significance as GAP = STEP = 0.5 mm, SD = 0.7, and Power = 0.8.

In TS images, the maximum gap and step values were measured in slices where the intra-articular dislocation appeared the greatest in lateral and frontal views **(Fig. 1)**.

In Xp images, the radial inclination (degrees), ulnar variance (mm), and volar tilt (degrees) values were measured **(Fig. 2)**.



TS Radiography/Reconstruction Parameters
Acquisition time: 5 sec.; Frontal sections: 3 to 40; Sagittal sections: 4 to 50; Slice pitch: 2 mm; Reconstruction method: FBP; and Filter: Thickness++
System used: Shimadzu fluoroscopy system

Fig.1 Example of Gap and Step Measurements by TS

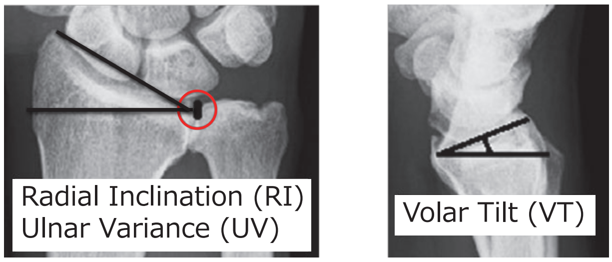


Fig.2 Example of RI, UV, and VT Measurements by Xp

4. Results

In TS evaluations, there were no significant differences in GAP or STEP values between in images acquired one day after and the ones acquired twelve weeks after surgery **(Table 1)**. In TS images, the number of cases are three (4 %) for GAP and two (3 %) for STEP that show dislocations of 2 mm or more after one day, and one case each (1 %) after twelve weeks.

In XP evaluations, there were significant differences in UV images between one day and twelve weeks after surgery **(Table 2)**.

Three cases are shown in **Fig. 3 to 5** (a case where the fracture was retained in the reduced position without dislocation, a case where the measurement value improved due to synostosis, and a case with a deviation in the screw oriented toward the styloid process).

5. Discussion

The number of corrective loss after locking plate surgery was small in other reports listed in **Table 3** or in the research. There was almost no correction loss in GAP or STEP values either.

Table 1 TS Evaluation Results

Evaluation Parameter		After 1 day	After 12 weeks	Difference	95 % CI	P-Value	
GAP (mm)	Mean Value (SD)	0.4 (0.8)	0.3 (0.6)	-0.1	-0.3 to 0.0	0.13	＊
	Median Value (1st and 3rd quartile)	0.0(0.0, 0.9)	0.0(0.0, 0.6)			0.18	#
STEP (mm)	Mean Value (SD)	0.3 (0.7)	0.3 (0.5)	0.0	-0.1 to 0.0	0.47	＊
	Median Value (1st and 3rd quartile)	0.0(0.0, 0.0)	0.0(0.0, 0.0)			0.70	#
Intra-Articular Screw Protrusion (number)		1	1				

＊ Paired t-test, # Wilcoxon rank sum test

Table 2 Xp Evaluation Results

Evaluation Parameter	After 1 day	After 12 weeks	Difference	95 % CI	P-Value
UV (mm)	0.2 (1.2)	0.6 (1.3)	0.4	0.2 to 0.6	<0.001
RI (°)	21.8 (3.0)	22.2 (2.8)	0.4	-0.1 to 0.8	0.15
VT (°)	6.7 (4.3)	6.2 (4.3)	-0.5	-1.1 to 0.3	0.21

SD indicated in parentheses Applicable t-test

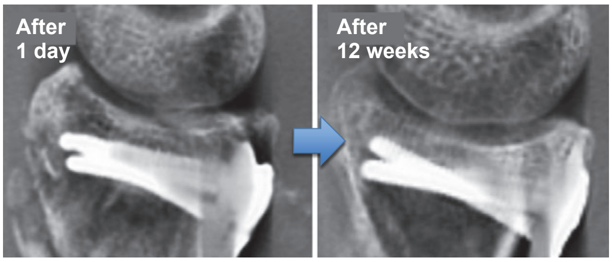


Fig.3 Case with Reduced Fracture Position Maintained without Dislocation

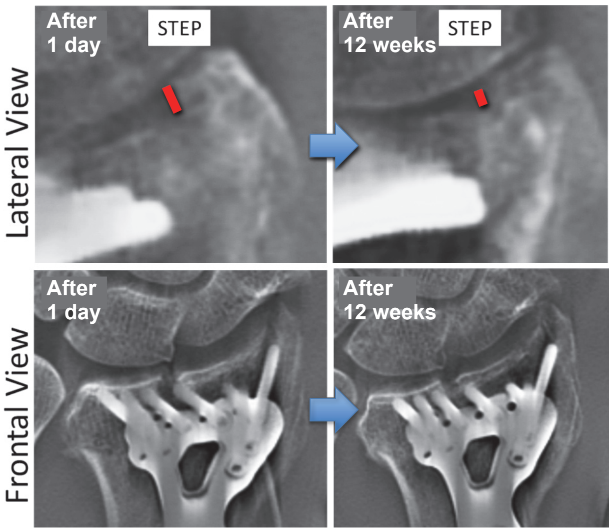


Fig.4 Case with Measurement Value Improvement Due to Synostosis

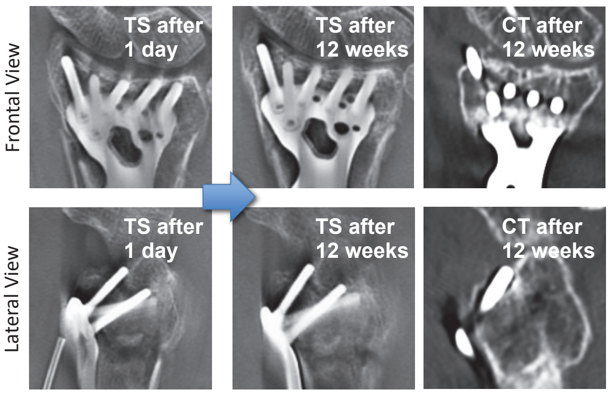


Fig.5 Case with Deviated Screw Oriented toward Styloid Process

A benefit of TS is minimal affection by metal artifacts, while providing diagnostic accuracy equivalent to CT for intra-articular discontinuities[6]. Furthermore, TS requires lower X-ray dose levels than CT (19.8 mGy for CT versus 0.72 mGy for TS)[9]. In contrast, TS fracture diagnostic accuracy is superior to Xp but inferior to CT[7].

The reliability of CT measurements by Yamazaki et al. is indicated in Table 4. The reliability of TS measurements was determined based on the inter-rater reliability of evaluations one day after surgery. That reliability level was moderate-to-substantial, as shown in Table 5.

Table 3 Correction Loss after Locking Plate Surgery for a Fracture of the Distal Radius[2),3),4)] Compared to the Given Research

	Cases	Evaluation Timing	UV (mm)	RI (°)	VT (°)	GAP (mm)	STEP (mm)
Kawasaki	49	20M	0.8	0.8	0.5		
Stone	268	6W		0	0		
Neuhaus	364	3M	0.7	1	1.2		
This Research	69	3M	0.4	0.4	0.5	0.1	0.0

Less than clinical significance (0.5 mm) in this research

Table 4 CT Measurement Reliability

CT Measurement Reliability for Intra-Articular Dislocations[8)]
Gap ICC (2.1) : 0.91 (0.85-0.94)
STEP : 0.90 (0.84-0.93)

Table 5 TS Measurement Reliability

Evaluation Parameter		ICC (2.1)	95% CI	P-Value	Landis Classification
ICC (1.2)	GAP	0.89	0.83~0.93	<0.01	almost perfect
	STEP	0.79	0.68~0.87	<0.01	substantial
ICC (2.1)	GAP	0.57	0.38~0.71	<0.01	moderate
	STEP	0.54	0.35~0.69	<0.01	moderate

Limitations of this research include a lack of a diagnostic gold standard (true intra-articular dislocation values determined by CT, for example), selection bias in the 21 unexamined cases (24 %), and the unknown effects (intra-articular dislocation) of synostosis after 12 weeks.

6. Summary

There was good reduced position retention within joints up to twelve weeks after locking plate surgery for intra-articular fractures. The results suggest TS provides utility for intra-articular evaluation after surgery.

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Stories of Kyoto-born Masterpieces — ㉑

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

The varying sizes, colors, and shapes of *Kyo-koma* give them an elegance unique to Kyoto. The red spinning top at the front is a classic type made from Nishijin-ori fabric.

Kyo-koma Spinning Tops

When one thinks of spinning tops, most likely what comes to mind is a round wooden or metal body with a spindle passing through the center. In Japan, they are often a source of enjoyment for family and friends at New Year, and are spun by either hand or string.

One major difference between the spinning tops mentioned above and *Kyo-koma* is the material used to make them. Interestingly, *Kyo-koma* are made using pigment-dyed, flat cotton thread, which is then wrapped around a spindle. The flat thread is so thin, in fact, that even knowing it is cotton, with its texture and weight, one could be forgiven for mistaking it as paper.

It is thought that *Kyo-koma* were first produced in the Azuchi-Momoyama period (1574–1600), where they were a favored pastime for upper-class women. At the time, kimono materials were used as the material, and the spindle was made of bamboo. As now, the material was wrapped around the spindle, and fixed with starch glue. The simple method of wrapping cloth around a core has been used since long ago: in the Nara period (710–794), for example, Buddhist images were created using a method known as *kanshitsu*, in which layers of hemp cloth soaked in lacquer were wrapped around a core.

Simple work but a stunning finish

It was in the early Showa period (1926- 1989) that *Kyo-koma* came to be produced using flat cotton thread. The process is simple—flat thread is wrapped around a spindle, while only glue and scissors are needed. Key to the process, however, is dependence on "feel."

To begin, the prewrapped colourful threads are unwrapped, and while straightening the thread through the fingers, the end is glued to the spindle. At first, the thread must be carefully and tightly wrapped, and thereafter it is wrapped at a fixed degree of pressure. Adjusting this pressure requires experience, and wrapping the thread perpendicular to the spindle is another challenge. While wrapping and maintaining the same width with the right hand, the left hand is used to guide the thread into shape. Rhythmically and at a good tempo, once the first color is complete it is time to move onto the next. The different color threads mustn't overlap at the seams, and leaving a minute gap between the two, the next thread is glued on, and wrapping begins again. It is delicate work—even a minor overlap between

Straightening out the flat cotton thread. There are 15 traditional colors that are commonly used, including red and yellow.

While wrapping the threads horizontally at a good rhythm, Nakamura can talk to customers during production. As such, he often performs sales demonstrations at various events.

Using *Kyo-koma* techniques, Nakamura also creates ornamental, miniature Gion Festival floats. During the festival, he hosts a sales booth near the actual floats.

Checking whether the thread is horizontally wrapped at a uniform width. If any threads stick out, it is cut off with scissors.

All *Kyo-koma* are checked to see whether they spin properly. As they are light and easy to spin, they are perfect for beginners and children.

Unique Kyoto vegetable-themed spinning tops, such as those resembling Kamo eggplants and Shogoin turnips, are especially popular souvenirs.

threads can offset the horizontal shape.

As the circumference widens, the tightness of the wrap can be relaxed, before being finally fixed with glue. The wrapping itself only takes around 20 minutes; once complete, the threads are moved up and down and loosened, the overall firmness is made uniform, and after ensuring the surface is smooth, the spinning top is made into a cone shape. Next, uniform width of the color pattern is checked from the side, the top is given a test spin, and after other minor adjustments, it is finished with a coating of urethane or varnish.

Modifying methods to expand business

In the early Showa period (1926- 1989), there were 10 different *Kyo-koma* shops in Kyoto; now, however, only Jakkyu near Nijo-jo Castle remains. As *Kyo-koma* were all hand-made, they couldn't be mass-produced, and—while not exactly expensive—could only be sold wholesale to souvenir shops. As a result, *Kyo-koma* craftsmen had no choice but to discontinue their businesses. "My father, too, stopped the business and moved on. Personally, however, I couldn't forget the feeling of seeing the *Kyo-koma* I'd helped create as a child line up at the front of the store, so I quit my job as a white-collar worker and chose this path," says Yoshiyuki Nakamura of Jakkyu.

Nakamura began selling the spinning tops wholesale, but later set up his own store. He is now much more well-known, and among others, is invited to events at department stores. There was no change in the low unit cost and the time and effort required to create *Kyo-koma*, however. And so Nakamura came up with an idea to streamline his work. He asked a dyeing shop to dye the threads so he could focus on the wrapping process. Moreover, he modified his predecessors' methods of measuring the wrapped width with a ruler, instead deciding on the necessary length of thread beforehand, eliminating the measuring process entirely. In this way he succeeded in shortening the work time for each spinning top, enabling him to deliver *Kyo-koma* to a much wider audience. Nowadays, Nakamura also creates seasonal decorations with spinning top motifs. Spinning tops are a lucky charm, and the *Kyo-koma* business is going from strength to strength.

Special thanks to: Kyo-koma Jakkyu; +81-75-811-2281

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