

SONIALVISION G4 High-Performance R/F System and its Tomosynthesis, SLOT Advance, and Bone Density Measurement Applications for High Quality Diagnosis



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1. Introduction

Our clinic started business on April 1, 2016 in Dairishinmachi, Moji-ku, City of Kitakyushu, Fukuoka Prefecture, Japan (**Fig. 1**). Kitakyushu is a government-designated city with a population of around 1 million people, and is the second largest city in Fukuoka Prefecture after Fukuoka City. The city first grew as the gateway to the Kyushu region, and was a big city in the era of abundant secondary industry and known as one of Japan's four major industrial areas. However, amid the decline of Japan's secondary industry and a shift in freight traffic away from sea routes to land and air, its role as the gateway to Kyushu faded and the effects of recession saw a slowly declining population. City of Kitakyushu has the highest population aging rate of all government-designated cities in Japan, and is a region where social welfare and medical services are both important. However, since the region also has a relatively large population and well-developed industry, there are many large public hospitals, Rosai hospitals (hospitals for occupational health), hospitals managed by corporate enterprises or public corporations, and university hospitals. City of Kitakyushu is a convenient place to live being on the Nozomi Shinkansen (bullet train) line, having an airport inside the city, experiencing no natural disasters such as earthquakes or typhoons, being situated close to both sea and mountains, and being known for delicious food. City of Kitakyushu was even chosen as the number one city to want to live in by elderly people of Japan.

I myself was born and raised in Kitakyushu, graduated

from the University of Occupational and Environmental Health, Japan, which is local to the area, and decided to open my clinic here because of ties to the city. My specialty was orthopedic surgery with an interest in pain and functional impairment, but seeing the need for rheumatoid arthritis (RA) medicine, I became a specialist in the field and made it my life's work. Based on this background, I had a number of aspirations for my clinic. These were a focus on the importance of musculoskeletal rehabilitation facilities, to create surroundings for the provision of RA treatment, and to obtain the diagnostic imaging systems needed for diagnosis and treatment.

Orthopedic surgeons treat a wide range of patient ages across a variety of fields of medicine. These include sports injuries experienced by children between elementary and high school ages as their body is growing and they are engaging in sports to improve their skills. Making a correct diagnosis is important, though appropriate treatment and guidance must also be selected based on evaluating the motor skills so far acquired by the patient, aptitude and basic physical fitness, and level of athletic ability. As people age and opportunities for exercise decrease, muscles that support and move the body weaken, the body stiffens, and pains emerge in various areas of the body that are not attributable to sports or a particular event. Then, as people further advance in age, they may need medical care for injuries sustained during trivial everyday activities. Orthopedics is also special among fields of medicine in that many otherwise healthy people must be examined who visit for minor pains in their lower back, neck, or joints. Since many different age groups and symptoms present at the clinic, our team includes 5 physical therapists with a wealth of experience, including a therapist with experience treating currently active athletes, a therapist with experience treating brain and spine surgery at a university hospital, and an athletics trainer. The clinic also has a variety of equipment and a large rehabilitation room (**Fig. 2**). Also, though biological drugs have become the prevailing treatment for RA and outpatient chemotherapy is now a common occurrence, though a clinic we have obtained in-hospital blood testing equipment to provide complete diagnosis and treatment, and also prepared a dedicated chemotherapy room for patients to relax during long treatments and also prevent



Fig.1 Takeuchi Rheumatism Orthopedic Surgery Clinic

spread of infection. Furthermore, as an orthopedic surgeon I insist on good quality X-ray diagnostic imaging, and so obtained Shimadzu's SONIALVISION G4 diagnostic imaging system that is also to perform tomosynthesis (digital multi-slice tomography) (**Fig. 3**).



Fig.2 Rehabilitation Room



Fig.3 The Author and SONIALVISION G4

2. Bone Mineral Density (BMD) Measurement and the Utility of Tomosynthesis in Diagnostic Imaging, in Particular for the Treatment of Vertebral Fracture

As an orthopedic surgeon I have particular priorities, and while many different tests are important in the diagnosis of arthralgia, low back pain, and pain during exercise, I consider X-ray diagnostic imaging of prime importance. As a result, tomosynthesis, SLOT Advance (SLOT radiography), and BMD measurement (for the Japanese market only) applications were obtained for our SONIALVISION G4 R/F system. Tomosynthesis in particular has recently garnered attention, and in orthopedic surgery is very effective for specialty imaging of the spine and spinal canal, and for diagnosis of fracture, bone union, and pseudoarthrosis. Of these uses, tomosynthesis can visualize "vertebral body end plate or anterior wall discontinuity" and "trabecula fracture inside the vertebral body" early after injury, reducing the number of times that a fresh vertebral fracture is overlooked

(**Fig. 4**). In particular, tomosynthesis provides clear images of even thoracic vertebrae that are difficult to visualize due to overlapping ribs and in cases of severe scoliosis. Tomosynthesis is also effective at visualizing the spinal canal, and provides distinct visualization of ossification of the posterior longitudinal ligament (OPLL) and spinal canal displacement due to vertebral fracture. Since the G4 system can also perform BMD measurement simply by adding the application software, once a vertebral fracture has been evaluated with lateral spine tomosynthesis, we can then also measure BMD without moving the patient to the other equipment. Furthermore, BMD measurement with G4 is extremely quick and easy, and patients are happy with the experience saying it does not hurt as there is a well-cushioned cover on the examination tabletop. The tabletop can also be lowered to a height of 47 cm making it easy for patients to move onto and off the radiography table. When even this height poses difficulty for getting onto or off the table, the patient can step onto the table in an upright position, and the table then moved to horizontal for supine imaging. Patients are overjoyed with this feature.



Fig.4 Tomosynthesis of Vertebral Fracture

3. Utility of Chest Tomosynthesis for Pulmonary Complications of Rheumatoid Arthritis

RA is treated both by specialists of internal medicine and orthopedic surgery, but since RA causes systemic complications as well as joint symptoms and with chemotherapy having become the main mode of treatment, there is an increasing number of internal medicine specialists. Of course, treatment for RA is a specialty aimed at improving joint symptoms, and specialists in orthopedic surgery are adept at examining the joints. As a specialist in orthopedic surgery myself, my view is that early diagnosis of RA is the most important factor for successful treatment, though early

Clinical Application

discovery of complications and adverse events is also important and requires monitoring, such as checking vital signs, collecting blood, and diagnostic imaging. My base treatment for RA is MTX, and when MTX is ineffective or has inadequate effect, I use biological drugs and surgical procedure. Experience has shown me that the most important adverse events involve the liver, lungs, kidneys, infections, and cardiovascular disease. Malignant tumors are also important. Although patient monitoring is important for treatment, both at the start and periodically during treatment, general tests of peripheral blood and chest imaging are also extremely important for early disease discovery, to the extent a patient's life can depend on them. Chest radiography is important, but diagnosis is normally performed with computed tomography (CT). However, a CT imaging system is of no benefit to an orthopedic surgeon, and instead my attention fell on tomosynthesis. Using tomosynthesis on the chest provides clear visualization of interstitial pneumonia, tuberculosis, lung cancer, lymph node metastasis, and other pathologies. The flat panel detector (FPD) used by tomosynthesis also brings a substantial reduction in X-ray dose, and gives images comparable or superior in clarity to CT at an X-ray dose lower than conventional diagnostic imaging systems. Although the literature on chest tomosynthesis is not extensive, the clarity of visualization of bronchi, blood vessels, and lungs it produces suggests that even I, who is not a specialist in radiology, could use them for early RA discovery. One of the major motives for obtaining the expensive tomosynthesis application was having decided that chest tomosynthesis is a very effective imaging modality when a clinic examines RA.

4. Utility of SLOT Radiography (SLOT Advance)

SLOT radiography is very useful to the field of orthopedic surgery as it produces frontal images of the whole spine and images of the entire lower extremities. However, conventional methods of long view radiography needed the dedicated film, or needed to perform segmented radiography then required substantial labor to combine the images later. Regardless, the X-ray angles of incidence were not in parallel for whole imaging area and the results were not accurate. The SONIALVISION G4 system moves the radiography arm parallel to the tabletop so the user needs only to configure imaging start and end points and commence an exposure, while the system automatically carries out all other procedures from combining and reconstructing images and image adjustment to displaying images on the monitor (**Fig. 5**). The fluoroscopy table also has a tilt function that allows smooth transition between standing and supine positions, reducing the burden on the patient. Using slot shaped X-rays for imaging allows SLOT radiography to acquire high quality images with reduced effects from scattered radiation at low exposure doses. X-rays



Fig.5 SLOT Radiography Image

also incident at close to perpendicular to the subject, reducing distortion in the longitudinal direction and allowing highly accurate measurements. Previously, long view radiography involved a lot of work though it was important for patient instructions and functional assessments, but with G4 system, SLOT radiography can be performed by just an additional application software, showing how impressive the SONIALVISION G4 system is. Another thing I have discovered is the ability of the system to acquire frontal and lateral images of the whole femur in young patient with long legs at a single command, something which we previously had difficulty with.

5. Conclusions

Shimadzu's SONIALVISION G4 high-performance R/F system has some very impressive features. The system is of course easy to use, but most importantly the image quality is excellent. The advancements being made in digital imaging are a constant wonder. Trabecular bones and soft tissues are clearly shown, and enlarged images are visualized without pixel pattern as seen with the older digital imaging systems. Other large hospital seems to be using relatively modern FPD systems made by another large manufacturer, but their images have obvious graininess.

Of special note is that while this is a new system with a few minor shortcomings, Shimadzu representatives are always ready to accommodate inquiries quickly and in earnest. I would like to take this opportunity to thank them for all their help.