Rad Fan

Vol.9 No.1 2011 January

Utility of tomosynthesis in the orthopaedic surgery at the Sumitomo hospital

Department of Radiology, Sumitomo Hospital

Masanari Taniguchi

Utility of tomosynthesis in the orthopaedic surgery at the Sumitomo hospital

Department of Radiology, Sumitomo Hospital
Masanari Taniguchi

Introduction

Sumitomo Hospital was first established in July 1921 as Osaka Sumitomo Hospital, with the philosophy of "Contributing to society with highly reliable medical care". The establishment of our new hospital was completed on September 1, 2000, renewed as the "New Sumitomo Hospital" worthy to be called a 21st century hospital, with enriched facilities and various systems for advanced and high quality medical services. Sumitomo Hospital is a special function hospital which is a core hospital in the area, providing high quality care not only for the employees of Sumitomo Group companies and their families but also for the general public. In the hospital, we use SONIALVISION safire series, which were installed in September 2008, as the main facilities in a diverse range of departments, such as orthopedics, gastrointestinal imaging, non-vascular IVR, swallowing contrast study and lower extremity venography. Direct conversion FPD has the vertical and horizontal useful field of view of 17 inch, with a rectangular screen free of distortion and halation. Also, the wide dynamic range enables adequate observation under fluoroscopic guidance, and is able to provide highly precise images.

System configuration of the device used

SONIALVISION safire series (Shimadzu Corporation)

Principle and characteristics of tomosynthesis

The principal characteristic of tomosynthesis using direct conversion FPD is the ability to reconstruct any coronary image at any position, by obtaining 36 to 74 images (parallel to the tabletop) in one scan, then digitally processing these images. Two methods are used as a summary of image reconstruction; the Shift-add method (hereinafter referred to as the SA method) where the image is reconstructed by conducting pixel shift on tomographic plane in proportion to the distance moved; and the filtered back projection method (hereinafter referred to as the FBP method) which uses CT reconstruction as its base, with artifact reduction processing added by adjusting reconstruction function. Main characteristics are shown below: (i) the FBP method produces tomographic images with fewer artifacts in the SI direction compared to the SA method, but results in a thicker effective slice. (ii) The field of view is large with 17 inches horizontally and vertically, enabling uniform images without distortion even in the periphery. (iii) There is only a little impact of metal artifacts like those seen in CT. (iv) The high contrast and high resolution in direct conversion FPD enables tomographic imaging at high resolution. (v) Although the exposure is at a low dose (twice the plain radiography used in the ortho-paedic surgery, around 1/10 of chest CT screening), a high-precision tomographic images can be obtained. (vi) Tomographic images can be obtained in any position (standing, supine, tilting), while applying a burden to the observation area. (vii) The process requires a short time from the patients, and also a short time for patients to retain the position, thereby significantly reducing patient discomfort. Also, throughput is at an adequate level. (viii) Image checking is simple, and the patient examination efficiency has been improved dramatically.

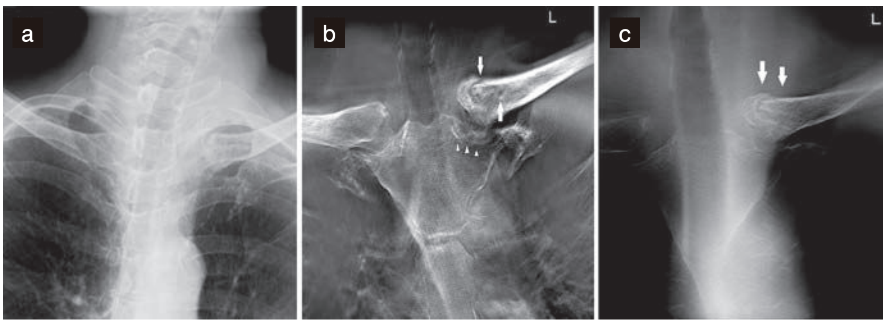

Figure 1 Tomosynthesis of the sternoclavicular joint
a: Evaluation with sternoclavicular joint and sternum XP is difficult due to many overlapping anatomical stracture
b: Tomosynthesis image, compound fracture and dislocation of the proximal section of the clavicle are observed (swing angle at 40 degrees, slow speed FBP method, 1 mm thickness ++ 100%)
c: Tomosynthesis image, follow-up observation (swing angle at 40 degrees, slow speed SA method, 2 mm thickness ++ 100%)

Comparative investigations of clinical images

Here, the clinical cases from the orthopaedic surgery are presented.

Clinical case 1: Sternoclavicular joint, sternum (Figure 1)

Tomosynthesis was conducted for a dislocation of the left sternoclavicular joint and a displacement of the proximal end of the clavicle due to fracture (**Figure 1b, down arrow**) and also for follow-up observations. As a result, callus was observed (**Figure 1c, down arrows**).

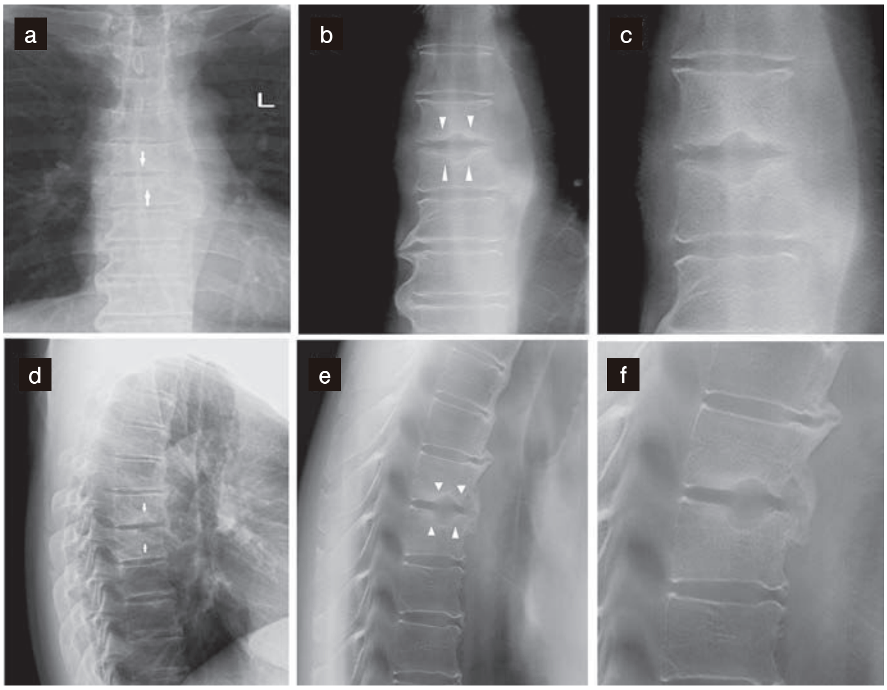

Figure 2 Tomosynthesis of the thoracic vertebrae

a: Moth-eaten pattern in the frontal thoracic XP image, at the up arrow
b: Frontal tomosynthesis image, Schmorl nodules and bone spur to the side (swing angle at 40 degrees, slow speed FBP method, 2 mm thickness ++ 100%)
c: Zoomed frontal tomosynthesis image, Schmorl nodules
d: Moth-eaten pattern in the lateral thoracic XP image, at the up arrow
e: Lateral tomosynthesis image, pointing out Schmorl nodules and ossification of anterior longitudinal ligament (swing angle at 40 degrees, slow speed FBP method, 2 mm thickness ++ 100%)
f: Lateral tomosynthesis image, Schmorl nodules and bone spur

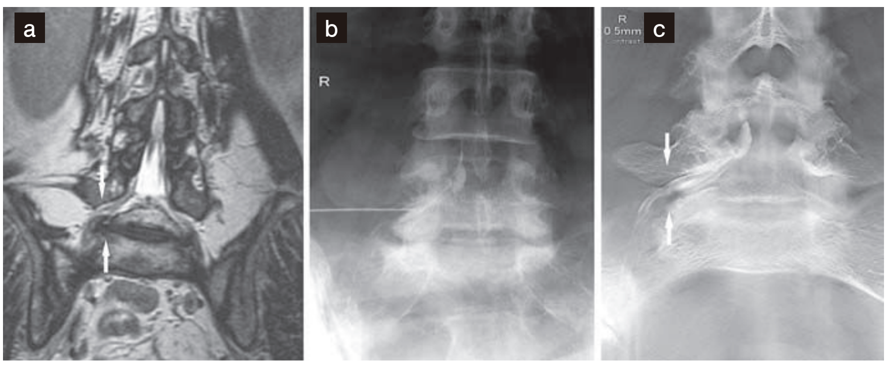

Figure 3 Tomosynthesis after nerve root block in the lumbar vertebrae

a: MRI 3D-T2FRFSE coronal image, nerve root compressed by right disk herniation
b: L5 nerve puncture image
c: Tomosynthesis image after nerve root imaging, contrast media flow is obstructed beyond the arrow (swing angle at 40 degrees, slow speed FBP method, 0.5 mm, Contrast 150%)

Clinical case 2: Thoracic vertebrae (Figure 2)

In thoracic vertebrae XP, vertical irregular patterns were observed in the endplate between Th 6/7, slightly anterior to the vertebral body (**Figure 2a, d, up arrow**). Tomosynthesis was conducted for this reason. By wide-ranging (17 inches) and highly precise tomographic imaging, ossification of anterior longitudinal ligament was observed in between multiple vertebrae, as well as a line similar to that of bonification was observed in a section of the endplate. From these findings, a possibility of ankylosing spondylitis and a suspicion of Schmorl nodules have been pointed out.

Clinical case 3: Post nerve root block (Figure 3).

Normally in a nerve root block, a radiographic image is taken at paracentesis for confirmation. However, the additional tomosynthesis imaging was useful in this hospital, so we will introduce such a case.

The lumbar spine MRI coronal image (**Figure 3a**) pointed out the disk herniation at L5 towards the right. However, MRI cannot be conducted in some cases due to pacemakers and ferromagnetic metals in the patient body. It is also not suitable for metal artifacts from surgical operations such as PLIF, or for patients who cannot hold still. Tomosynthesis procedures are extremely useful for such cases. In the tomosynthesis image after nerve root block imaging (**Figure 3c**), the shape of the disk as a soft tissue, cannot be observed. However, tomosynthesis provides a clear image of the complex lumbar spine joints as well as the superior articular process and lumbosacral joint in the sacral spine. This enables diagnosis to exclude physical nerve compression due to bone deformation. The image has revealed that the contrast media is flowing upwards from the position shown with a down arrow without obstruction, but the flow downward is inhibited by nerve compression. This additional image enabled accurate investigation of the shape of the nerve root, as well as narrowing down the location of the lesion.

Clinical case 4: Post hip arthrography, after surgery for hip osteoarthrosis (Figure 4)

This case is introduced since the additional tomosynthesis imaging carried out immediately after arthrography in this hospital was useful for diagnosis.

Right hip osteoarthosis was observed in the plain radiography, then arthrography was carried out by tomosynthesis and CT imaging for suspected FAI (femoro-acetabular impingement).

Since tomosynthesis provides antero-posterior depth information almost without being affected by artifacts from contrast media, it enables observations such as thickness of joint space, thickness of articular cartilage, shape of articular lip and also of the ligaments. The image provides a highly precise picture of bone fracture, deformation, bone cysts, leakage of contrast media between tissues and damage locations. With CT, observation from various angles is possible by creating MPR and VR, etc., but the spatial resolution is low and therefore is not suitable for narrowing down on the fine damage locations. The high concentration of contrast media may impact imaging with artifacts, but tissue contrast cannot be obtained with low concentration. For these reasons, additional imaging by tomosynthesis is extremely useful for diagnosis, as it easily provides significant contrast between the tissues in arthrography.

After postoperative evaluation of OA, tomosynthesis was conducted. The image shows that the bone union between the site of rotational acetabular osteotomy and the grafted bone is partially incomplete, forming a gap. Also, the contact surface of the joint can be observed.

Clinical case 5: Calcaneus, toes (Figure 5)

Tomosynthesis can be used to clarify the state of bone graft, bone cysts and inflammation state in the calcaneus. Also, tomosynthesis enabled observation of strong sclerosing changes due to unevenness in joint areas of talus and calcaneus, as well as of erosion into the bone cortex.

Also, the evaluation of bone union was difficult in toe plain radiography, however tomosynthesis image showed a slight displacement in the fracture location and incomplete bone union. It is possible to make clear observation of factures with CT, however, it is difficult for CT to visualize callus formation and detailed trabecular bone images.

Conclusion

In this hospital, we set specific and original protocols for individual examination items, imaging technique and region at the lowest level of exposure required. Tomosynthesis is a examination method most suitable for the observation of fine displacement or fracture, callus or dissolution, state of bone union and the boundary between the artificial and natural bones, all of which is difficult to be visualized by plain

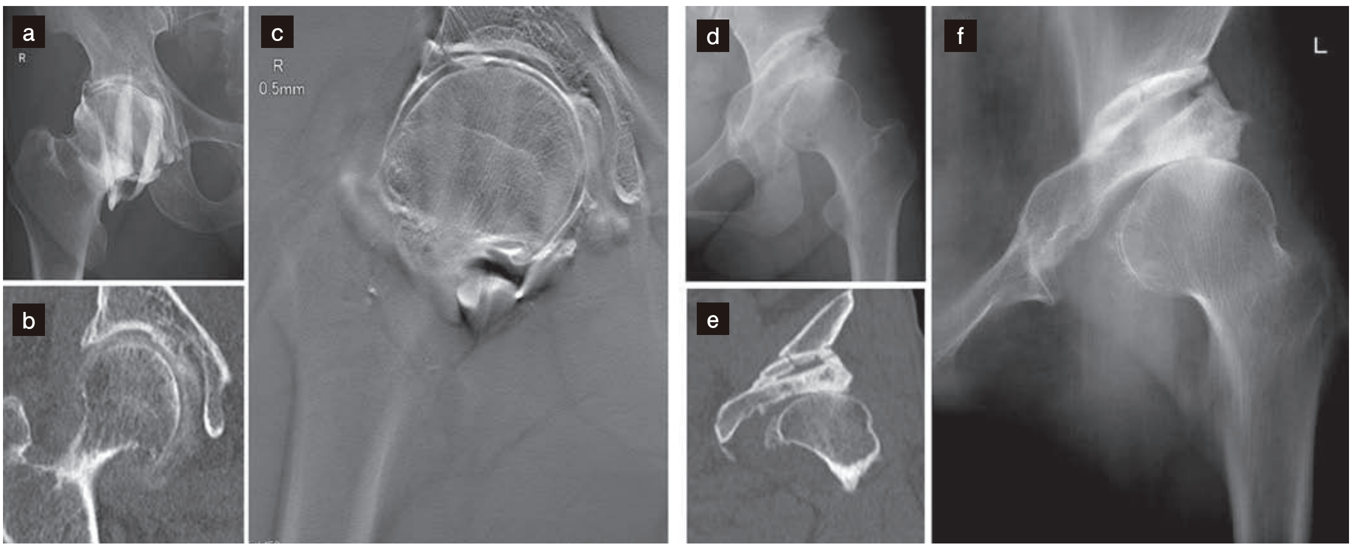

Figure 4 Comparison of hip joint tomosynthesis and CT

a: Right hip arthrography
b: Post-imaging CT MPR coronal image, can be observed at any angle, however difficult to evaluate articular cartilage
c: Post-imaging tomosynthesis image, able to measure thickness of inside of femoral head, joint space, articular lip and articular cartilage, as well as to observe the ligament of the femoral head (swing angle at 40 degrees, slow speed FBP method, 0.5mm thickness ++ 150%)
d: Frontal hip joint XP, undergone Rotational acetabular osteotomy (left side) at another hospital, then attended this hospital. Difficult to observe complex articular structure
e: Plain CT MPR coronal image, observation of false join is easy
f: Tomosynthesis image of the hip joint section, shows inflammatory image from the contact of joint space, as well as the incomplete bone union between the grafted bone and the rotational acetabular osteotomy bone (swing angle at 40 degrees, slow speed FBP method, 0.5 mm thickness ++ 150%)

radiography. Since tomosynthesis enables observation of bone destruction and deformation as well as the observation of bone erosion in trabecular bone images, it can be used for radiography of fingers and toes to evaluate chronic rheumatoid arthritis (RA). Although undershoot-type artifacts appear around the metal implants in the body, the wider dynamic range reduces the effect of metals compared to CT or MRI, thereby providing high-precision images. Furthermore, tomosynthesis is extremely useful for diagnostic imaging in the orthopaedic surgery, since it is possible to radiograph the location at a sitting or supine position or while fixing the affected location with a corset, etc., without applying burden to the location. Tomosynthesis produces two types (SA method and FBP method) of unique images, different from plain radiography, CT or MRI. These images have enabled imaging of wide-ranging and high-precision information which could not be obtained before. Also, tomosynthesis can be conducted as an addition to other methods. From these reasons, tomosynthesis can be said to have made a great contribution to the clinical areas. Here are the points of caution and problems encountered in our experiences: (i) Tomographic parameters are set for imaging of each patient, however the height, pitch, and the range of the layer are not always optimal. To obtain adequate images, there is a need to adjust the tomographic conditions at the workstation then reconstruct the tomographic desired image. (ii) To avoid the impact of the partial volume effect, care needs to be taken not to set the slice thickness greater than the imaging subject. (iii) The time required for image reconstruction and the transfer time to the hospital image server needs to be shortened. (iv) The burden on the hospital image server is great, since the amount of image data is great; and other points in addition to these. Although there is no doubt that tomosynthesis is a highly useful method in the orthopaedic surgery, there is a need to put continuous efforts to apply this technology in other clinical areas for the benefit of patients. In the future, we would like to focus on the imaging conditions and the image characteristics in investigating and putting in practice the image obtaining technique, so that the technology is of a further use in qualitative diagnosis.

Figure 5 Comparative evaluation of toe fracture and chronic osteomyelitis of the calcaneus

a: Plain CT MPR coronal image and axial image, observation can be made from any direction.
b: Tomosynthesis image of the toes, useful for observing fractures, callus formation, as well as the bone erosion in the trabeculae of RA patients (swing angle at 40 degrees, slow speed FBP method, 0.5 mm thickness ++ 150%)
c: Plain CT MPR sagittal image, enabling clear observation of fractures, bone graft status and cysts as with tomosynthesis images.
d: MRI T1-FSE sagittal image, observations show uneven joint surface, strong sclerosing changes, and suspicions for bone necrosis.
e: Tomosynthesis image of the calcaneus and tarsus section, image taken with the bases of both feet placed together. The arrows show cyst images and uneven sclerosing images in the joint section (swing angle at 40 degrees, slow speed FBP method, 1 mm thickness ++ 100%)