RAD

Introducing Tomosynthesis to our Hospital —From the Perspective of a Radiological Technologist—

Hidehiko Fukuoka, R.T.

Department of Radiology, Kariya Toyota General Hospital
Hidehiko Fukuoka

1. Hospital Introduction

Kariya Toyota General Hospital is a private medical institution located in Kariya City, Aichi Prefecture, that is operated by Toyota-Kai Medical Corporation (consisting of Kariya City, Takahama City, and 8 Toyota Group companies). The hospital is at the center of its 10-km radius medical catchment area and is responsible for providing medical care to around 700,000 people. The hospital has 704 beds, is certified as a critical and emergency care center, and handles all emergency cases from primary to tertiary level under the slogan “emergency care with an open door” 24 hours a day, 365 days a year.

2. Introducing and Operating Tomosynthesis

2.1 Introducing Tomosynthesis to our Hospital

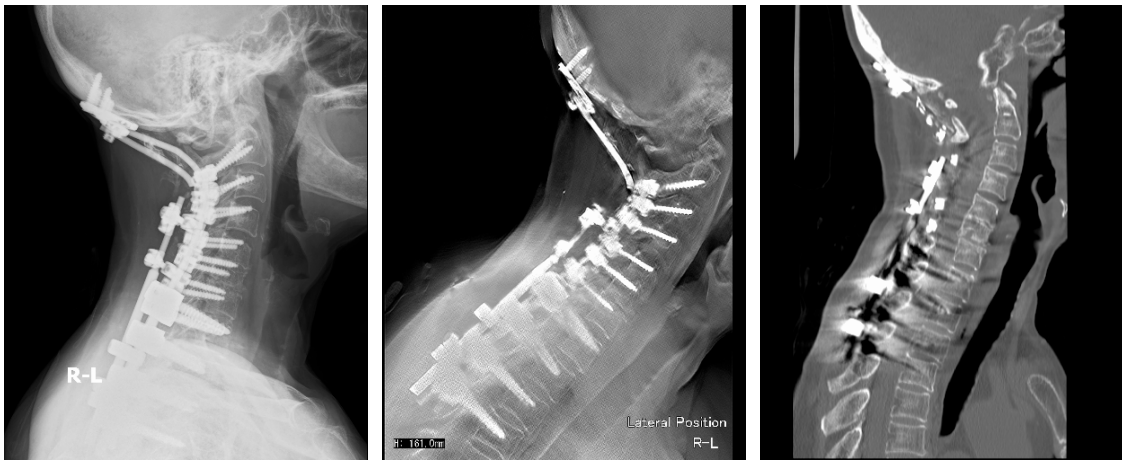
The general concept behind radiological examinations at Kariya Toyota General Hospital is that inpatient and outpatient examination rooms are operated separately out of concern for patient psychological wellbeing. In March 2020, a RADspeed Pro EDGE system was installed in the outpatient examination room area adjacent to the emergency room to replace aging equipment. In recent years, specialized examinations such as X-ray CT and MRI have come into widespread clinical use, and loss of staff interest in general radiography has been an issue for the radiology department. As a result, the decision was made to introduce tomosynthesis to the hospital to act as a “priming charge” in the field of general radiography.

To prepare for tomosynthesis at the hospital, briefing sessions on tomosynthesis were initially held for orthopedic surgeons, and brochures were prepared that explained tomosynthesis to patients. Since the hospital had no experience with tomosynthesis, orthopedic surgeons were told about the reduced X-ray dose levels to patients and the advantages of tomosynthesis compared to radiography and X-ray CT examinations. We also decided a certain number of cases and an exchange of views on images from those cases was needed to establish tomosynthesis at our hospital. First, a list of patients who had undergone total knee arthroplasty (TKA) and total hip arthroplasty (THA) was created each month, and cases were selected alongside the attending physician for whom tomosynthesis offered potential benefits. The brochure explaining tomosynthesis to patients was used to describe the benefits of tomosynthesis and the cost of the examination, and patients who provided assent underwent tomosynthesis.

2.2 Operating Tomosynthesis at our Hospital

As previously reported in this journal, tomosynthesis requires special imaging skills to obtain good quality images, such as positioning that takes the X-ray tube travel direction into consideration and firm restraint of patient movement. When tomosynthesis was first introduced and not well known at our hospital, physicians requested tomosynthesis in order to appraise the technology, hence reliable image quality was essential. To achieve this, during the initial stages of introducing tomosynthesis, on-the-job training was provided to around 10 members of staff with considerable experience in the general radiography section. After working on 3 to 5 general cases, staff members were able to perform tomosynthesis and subsequent image reconstruction unaided. However, cases with geometrically complex implants, such as the postoperative cases shown in **Fig. 1**, require special skills. Help from the manufacturer’s application specialist was sometimes requested to discuss examinations beforehand and watch the examination remotely.

Table 1 shows the number of tomosynthesis examinations performed in FY 2020 at our hospital. Tomosynthesis was most commonly requested



a) Radiograph b) Tomosynthesis image c) X-ray CT image

Fig.1 Posterior Occipito-Thoracic Fixation

Table 1 Tomosynthesis Examinations Performed at our Hospital (FY 2020)

Purpose of Request	Number of Cases	Percentage
TKA	62	39%
THA	50	31%
Post spondylodesis	27	17%
Assessment of hand bone union	5	3%
Assessment of insufficiency fracture bone union	4	2%
Spondylolysis	3	2%
Rheumatism examination	3	2%
Trauma examination	3	2%
Sacroiliitis examination	2	1%
Laminoplasty	1	1%
Post foraminotomy	1	1%
Total	**161**	

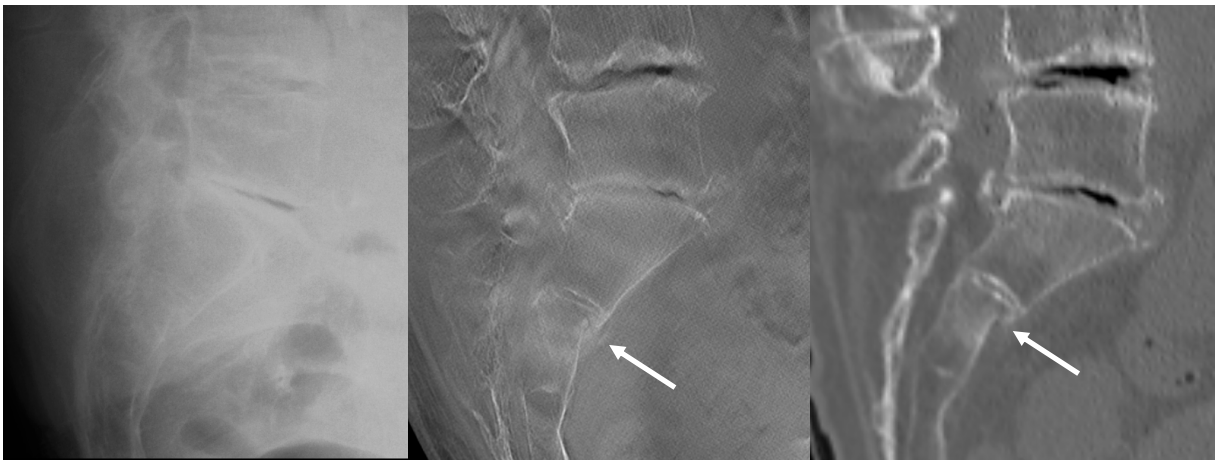
for TKA, followed by THA and post-spondylodesis. Because tomosynthesis produces fewer metal artifacts compared to X-ray CT and creates tomographic images with good in-plane resolution characteristics, we found it very useful in postoperative cases and the modality was highly rated by orthopedic surgeons.

A mini-conference with the requesting physician is also always held after an examination. This conference must be held promptly, and is used to exchange opinions on tomosynthesis image findings, image quality, and positioning, and implement improvements for subsequent examinations. Raw data (projected images) from tomosynthesis is also stored on the PACS server for use in medical treatment based on a request made by physicians in the mini-conference. Raw data can be evaluated in the form of a radiograph at any angle along the path of X-ray tube travel within the range of the set X-ray tube swing angle. Raw data is used to differentiate artifacts from other structures and to obtain information additional to that found in the radiographs. However, users are currently limited in the image processing parameters they can configure and apply to this raw data and image quality is inadequate. We hope this feature will be improved in the future.

2.3 Secondary Benefits of Introducing Tomosynthesis

Tomosynthesis was introduced to our hospital with the expectation it would act as a “priming charge” in the field of general radiography. Relatively large-scale medical institutions such as ours tend to provide fewer opportunities for face-to-face contact with physicians, but as described in the previous section, tomosynthesis has overwhelmingly increased opportunities for communication with the requesting physician. This communication is extremely useful and provides a lot of useful information about the needs of physicians not only related to tomosynthesis but also other modalities, and information about fields other than diagnostic imaging such as diagnostics and therapeutics.

Tomosynthesis has also increased discussion between radiological technologists. Tomosynthesis has reminded us of the importance of radiographic techniques such as correct positioning and firm restraint of patient movement. While tomographic image reconstruction allows the tomographic plane to be tilted up to 20 degrees in any position in the XY direction, good quality images require good projection data, which means good positioning. Less experienced staff say their radiographs have improved since they started working with tomosynthesis and their understanding of image anatomy has improved because tomosynthesis provides more opportunities to view tomographic images. We believe a secondary effect of introducing



a) Radiograph at initial examination b) Tomosynthesis image after 2 weeks c) X-ray CT image after 2 weeks

Fig.2 Sacral Insufficiency Fracture

tomosynthesis has been to improve awareness in the field of general radiography and improve radiographic techniques.

3. Clinical Cases

Three cases of tomosynthesis performed at our hospital are presented.

3.1 Sacral Insufficiency Fracture

A woman in her 80s visited the emergency room with a chief complaint of low back pain and no obvious episode of trauma. A radiograph from an initial examination showed no clear imaging evidence of the chief complaint **(Fig. 2 (a))** and the patient was sent home for therapeutic rest. When symptoms did not subside after 2 weeks, the patient visited our department of orthopedic surgery. Upon performing tomosynthesis, a clear fracture line was discovered in the second sacral vertebra along with a high absorption area suggestive of bone fusion on the anterior side **(Fig. 2 (b))** and the patient was diagnosed with a sacral insufficiency fracture. An X-ray CT image taken at the same time **(Fig. 2 (c))** revealed a discontinuous bone cortex, but tomosynthesis was able to visualize these findings more clearly due to its superior in-plane resolution characteristics. Tomosynthesis also uses a lower tube voltage than X-ray CT, which may be better for capturing the continuity of trabecular bone. A search of the literature on sacral insufficiency fractures found reports noting the difficultly of identifying fractures by radiography and the benefits of X-ray CT and MRI[1, 2], but this case points to the usefulness of tomosynthesis in identifying sacral insufficiency fractures.

3.2 Rheumatoid Arthritis

A woman in her 60s had received treatment for rheumatoid arthritis for the last 20 years and continuously undergone radiography of the hands and feet. A dislocation of the right third metatarsophalangeal joint was found, but bone breakdown could not be adequately discerned due to the metatarsal bone and proximal phalange overlapping on the radiograph **(Fig. 3 (a))**. Meanwhile, tomosynthesis allows observation of any transverse plane and was used to observe the metatarsal bone and proximal phalange separately in detail **(Fig. 3 (b))**.

Early bone erosion is a prognostic factor for poor outcomes and is important for deciding the treatment strategy for rheumatoid arthritis. Although bone breakdown is advanced in the present case, in cases where bone breakdown is at a relatively early stage, plain radiography is considered useful for making changes to medication and otherwise identifying timings for therapeutic intervention. The orthopedic surgeons at our hospital strongly believe that tomosynthesis may be capable of capturing findings of bone breakdown directly linked to treatment with greater sensitivity than plain radiography, and an investigation of this topic is currently underway.

3.3 Hip Arthroplasty

A woman in her 70s underwent hip arthroplasty for right hip osteoarthritis. A POLARSTEM (Smith & Nephew) fully HA-coated cementless stem was used. Radiographs and tomosynthesis images obtained during follow-up 2 weeks and 3 months after surgery are presented **(Fig. 4)**. Spot welds (SW), which are linear shadows indicative of bone formation, could not be identified in the radiograph at 3 months after surgery **(Fig. 4 (b))**. By contrast,

a) Radiograph b) Tomosynthesis image

Fig.3 Rheumatoid Arthritis

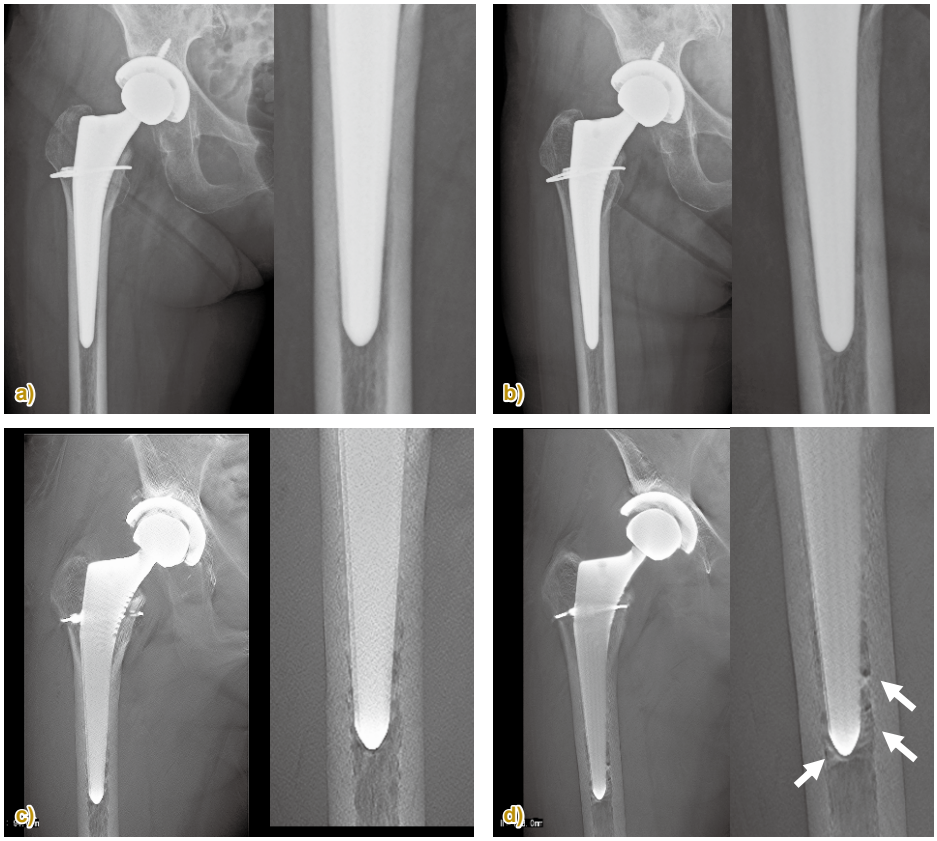


Fig.4 Hip Arthroplasty
a) Radiograph 2 weeks after surgery b) Radiograph 3 months after surgery
c) Tomosynthesis image 2 weeks after surgery d) Tomosynthesis image 3 months after surgery

SWs are clearly visualized by tomosynthesis in zones 4 and 5 at 3 months after surgery **(Fig. 4 (d))**. Biological fixation is important for favorable long-term outcomes, and this case demonstrates that biological fixation can be assessed earlier by tomosynthesis than plain radiography.

4. Future Prospects

As described in this article, tomosynthesis is currently used at our hospital primarily for postoperative cases in the field of orthopedic surgery, but we would like to expand its use to emergency room cases. Residents are often responsible for the majority of initial medical care provided in emergency room cases, and diagnostic imaging services outside

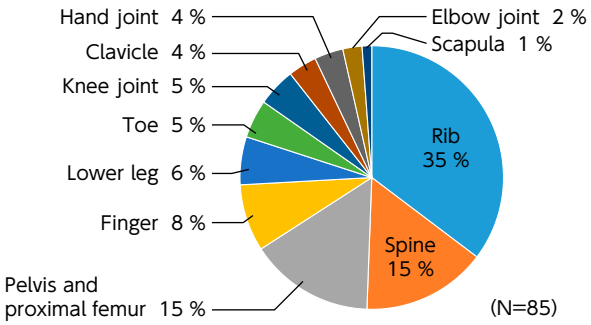


Fig.5 Fracture Sites Not Identified in Imaging Findings by Radiological Technologist in Out-of-Hours Emergency Examination (FY 2020)

of consultation hours at our hospital, such as at night or on holidays, appear to be unsatisfactory when compared to consultation hours. Therefore, radiological technologists provide medical support by helping to interpret radiographic images and reporting to the requesting physician upon encountering critical radiological findings. However, even our department frequently uses less experienced staff for out-of-hours care and critical finding reporting may sometimes be inadequate. **Fig. 5** shows the results by fracture site from an analysis of cases where fracture findings were not identified by the radiological technologist in emergency out-of-hours examinations in FY 2020. The most common site is the ribs (35 %), followed by the spine (15 %) and the pelvis and proximal femur (15 %). Based on this, we want to utilize the strengths of the RADspeed Pro EDGE, which can perform both radiography and tomosynthesis with ease, to strengthen medical support for emergency cases by using tomosynthesis when radiographs do not provide clear findings.

References

1) Takemoto T. et al. Pelvic insufficiency fracture: report of 12 cases. Orthopedic Surgery, 53: 1634-1639, 2002.
2) Serikyaku H. et al. Three cases of sacral insufficiency fracture. Orthopedics & Traumatology, 61: (3) 483-487, 2012.