R/F

# A New Side Station for T-smart

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## 1. Introduction

The Side Station is the image processing workstation that comes with the SONIALVISION safire Series multipurpose radiography/fluoroscopy (R/F) system, and the Cvision safire 17 C-arm model R/F system. The Side Station fulfills a variety of functions, including being a second control console to implement concurrent printing and network transfers while performing radiography, advanced image processing functions including multifrequency processing, and image reconstruction functions such as dual-energy subtraction, slot-scan radiography and tomosynthesis, an imaging application of the SONIALVISION safire Series. Here we introduce a newly developed Side Station that supports T-smart (Tomosynthesis – Shimadzu Metal Artifact Reduction Technology) and is designed to deliver fundamental performance improvements for tomosynthesis, a strong feature of the SONIALVISION safire Series, including improved processing speeds and new functionality.

## 2. Background

In recent years, R/F systems that have mainly been used for gastrointestinal examinations such as contrast imaging with barium contrast medium have been put to use in various roles including endoscopic examinations and non-vascular IVR. The SONIALVISION safire Series comes with various imaging applications such as tomosynthesis and slot-scan radiography that support diagnostic procedures in the field of orthopedics in addition to the applications mentioned above. The Side Station performs the image processing functions that generate reconstructed images from radiographic images taken by the system. Of the various imaging applications, tomosynthesis has superior characteristics in that it produces images with high spatial resolution equivalent to plain radiography and results in exposure doses lower than those obtained using CT. Utilizing this, tomosynthesis has been utilized as an excellent imaging method in orthopedics to acquire three-dimensional information able to depict fine structures inside the bone. We newly developed T-smart, a method of image reconstruction for tomosynthesis designed for use in the treatment using metal implants such as artificial joints that are extensively used in orthopedics in recent years.
Fundamental performance improvements have also been implemented that improve tomosynthesis in terms of reconstruction speeds and how images are viewed, to enable the use of tomosynthesis in concurrent diagnostic and treatment roles in areas other than orthopedics such as in endoscopy and non-vascular IVR. These functions are described in detail below.

## 3. T-smart (Option)

For artificial joints and other treatments that use metal implants, how the contact surface between a metal implant and human tissues such as bone changes over time is an important element in diagnosis. Conventional plain radiography that has previously been used predominantly for diagnosis can only produce a single two-dimensional X-ray image that has difficulty depicting the three-dimensional features of the metal and bone in detail **(Fig. 1 (a))**. While CT produces three-dimensional images, the metal used in artificial joints creates artifacts in the image that make image acquisition at the contact surface between bone and metal problematic **(Fig. 1 (b))**. In addition, for postoperative examinations, radiography must be periodically performed multiple times, which makes the exposure dose to the subject a significant problem. Tomosynthesis has a low exposure dose that results in fewer metal artifacts in principle and high spatial resolutions making the observation of finer detail possible in sites of interest, being cause for the recent use of tomosynthesis **(Fig. (c))**.
T-smart uses a newly developed tomographic image reconstruction algorithm combining iterative

approximation and a metal-isolating algorithm that further reduces the few metal artifacts that remain with tomosynthesis.

Iterative approximation involves comparing a generated tomographic image against an acquired image and iteratively correcting for errors, thereby creating an accurate tomographic image **(Fig. 2)**. By also implementing calculations in this iterative process that determine the degree of influence of metal and that reduce the effect of metal, metal artifacts are reduced **(Fig. 3)**. Also, by differentiating between metal and non-metal material, reconstructing separate images for each and finally combining those separate reconstructions we are able to substantially reduce metal artifacts **(Fig. 4)**. The above-described method of reconstruction can be applied to the images obtained using conventional tomosynthesis, thereby retaining the low exposure and high-resolution characteristics of tomosynthesis while also reducing the presence of metal artifacts.

**Fig. 5** shows a postoperative image after TKA (Total Knee Arthroplasty). Artifacts are substantially reduced around the metal parts in the conventional tomosynthesis image **(Fig. 5 (a))** relative to the CT image **(Fig. 1 (b))**. However, **Fig. 5 (b)** shows that artifacts are further reduced to the degree they are barely noticeable. This is particularly relevant in THA (Total Hip Arthroplasty) **(Fig. 6)** where reducing the presence of artifacts allows clearer depiction of trabecula (fine folds) inside the bone at points of contact with the artificial joint (bone ingrowth or bone ongrowth) **(Fig. 6 (b))**.

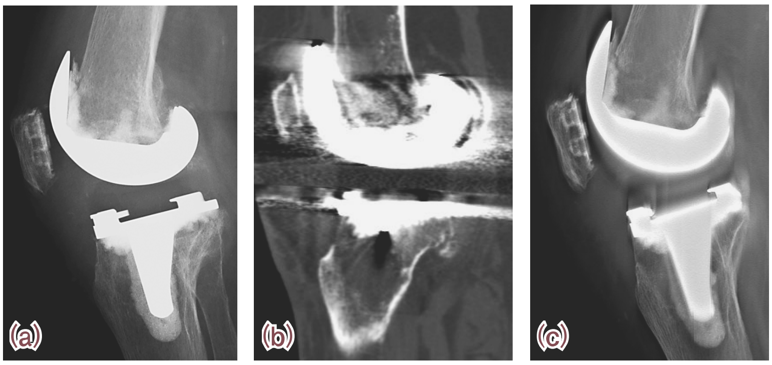



**Fig. 1** Differences in Radiographic Images of an Artificial Joint with Different Imaging Modalities
**(a)** Plain Radiography Image, **(b)** CT Image, **(c)** Tomosynthesis Image Courtesy of Hachiya Orthopedic Hospital

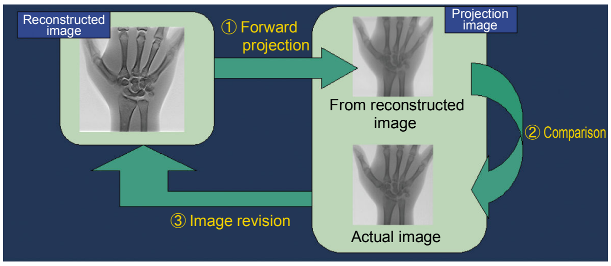



**Fig. 2** Principle of Reconstruction by Iterative Approximation

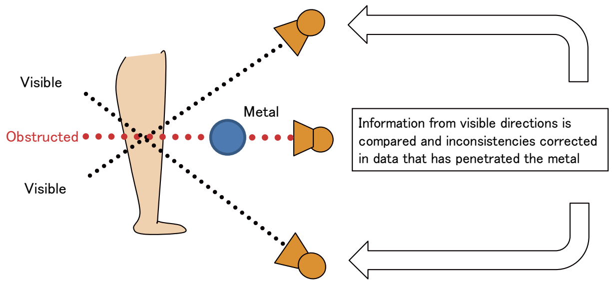



**Fig. 3** Principle of Reducing Metal Artifacts

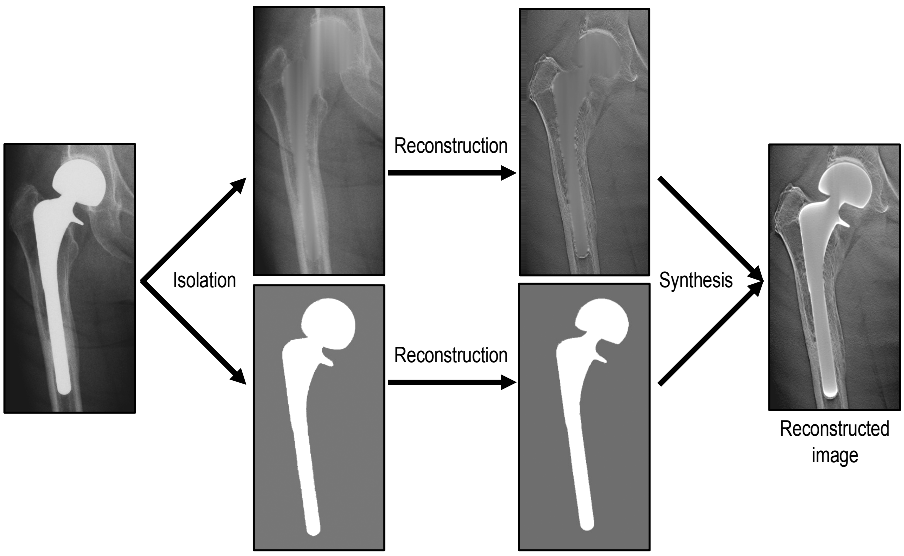



**Fig. 4** Principle of Metal Isolation Method

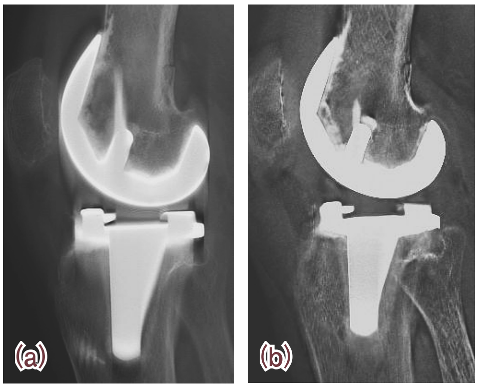



**Fig. 5** Tomosynthesis Images (Knee)
**(a)** Conventional Method Using FPB, **(b)** T-smart
Courtesy of Sonoda Joint Replacement and Sports Medical Center

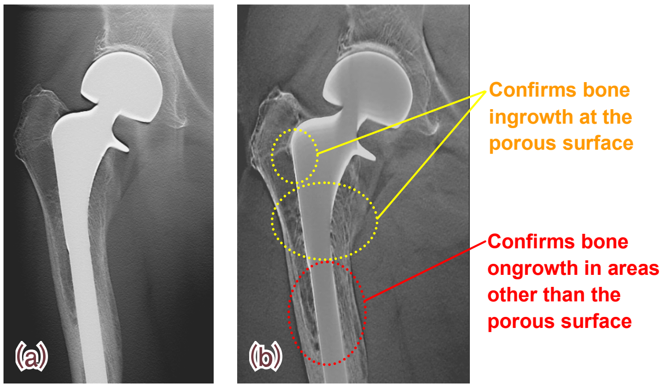



**Fig. 6** Tomosynthesis Images (Femur)
**(a)** Conventional Method Using FPB, **(b)** T-smart
Courtesy of Kanazawa University Hospital

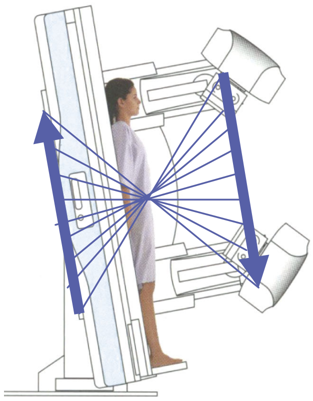
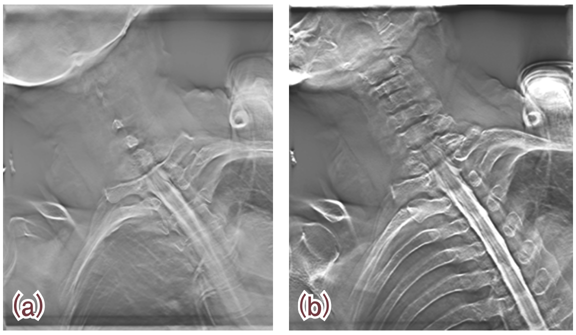


**Fig. 7** Tomosynthesis Radiography



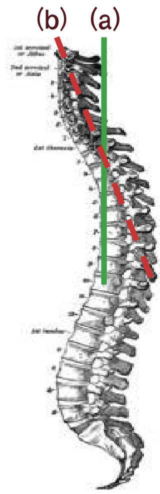




**Fig. 8** Oblique Section View Function
**(a)** Original Image View (Solid Line),
**(b)** Oblique Section Image View (Dashed Line)

## 4. Fundamental Performance Improvements Expanding Fields of Application

### 4.1. Oblique Section View and Save Functions

Tomosynthesis radiography scans along the body axis of the subject while the subject is lying on the radiography table **(Fig. 7)**. As a result, coronal section images are taken parallel to the radiography table and multiple tomographic images are obtained in a single scan along a given length of the subject.

Observing human body structures in three-dimensions has to date required scrolling through parallel sections with different heights. We have implemented an "oblique section view function" that enables images to be viewed and saved at oblique angles to the radiography table. This makes it possible to view and save images at planar angles that conform directionally with a specific or deformed area of interest. For example, this function may be used to view a wide region of the vertebral body in a single tomographic image **(Fig. 8)**.

### 4.2. Faster Tomosynthesis Reconstruction Times Relative to the Previous Reconstruction Method (FBP)

The FBP (filtered back projection) method employed to date had relatively short calculation times compared to the iterative approximation method. Now, high-performance PC and GPU (graphics processing unit) components have been used in the new Side Station to improve processing speeds and reduce reconstruction processing times to one quarter of previous times. This results in an increase in throughput for general radiographic examinations as well as improvements in operability concerning treatment applications. When used in conjunction with treatment procedures, such as endoscopic examinations and non-vascular IVR, treatments can be progressed in response to each image as it is produced, with the therapeutic course of action decided there. How quickly three-dimensional imaging results created using tomosynthesis can be viewed is an important factor in ensuring there are no interruptions in examination and treatment procedures. With the new Side Station, when using a 9-inch field-of-view it takes approximately 30 seconds to proceed from completed image acquisition to tomographic image reproduction. We believe this performance is sufficient for application in treatment-related procedures.

## 5. Conclusion

We have developed a variety of functions for the Side Station that allow for multipurpose use of R/F systems beyond the gastrointestinal examinations that have been their main application to date. By incorporating new functions into the Side Station, such as oblique section view and, more crucially, T-smart employing a new tomographic image reconstruction algorithm to reduce metal artifacts that are a principal obstruction in orthopedic examinations, and while simultaneously increasing tomosynthesis image processing speed, we have improved the scope of applications for R/F systems in a wide range of clinical fields. We anticipate the SONIALVISION safire Series R/F system together with the new Side Station will be used in a more multipurpose role in the future.

We would also like to take this opportunity to thank Hachiya Orthopedic Hospital for providing clinical data, and Kanazawa University Hospital and Sonoda Joint Replacement and Sports Medical Center for providing clinical analysis and valuable guidance in the development of T-smart.

**Reference**

Kazuhiro Mori, Kazuyoshi Nishino, Daisuke Notohara, Tomonori Sakimoto: Shimadzu Review Vol. 68 No.1–2 P29–33 (2011)