

Can T-smart Tomosynthesis Improve Diagnostic Accuracy on THA Component Stability?



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Yixin Zhou, professor of Beijing Jishuitan Hospital gave a presentation on the SONIALVISION safire R/F system at the “International Society for Technology in Arthroplasty” held in Kyoto, Japan on September 24 to 27, 2014. The contents of his presentation are introduced below.

1. Abstract

1.1. Background

The development of T-smart tomosynthesis has greatly improved the imaging quality of THA by reducing the peri-implant artifacts. In order to find out whether these improvements could lead to diagnostic advantages on stability of cementless THA arthroplasty components, we conducted a diagnostic research by comparing T-smart tomosynthesis, X-ray, and computed tomography.

1.2. Methods

We retrospectively included 48 patients who undergone THA revisions in our center between August, 2013 and March, 2014. For patients with hybrid fixation as their primary prosthesis, the femoral or acetabular components with cement fixation were excluded. There were 41 cementless femoral stems and 35 cementless acetabular cups remained for evaluation. All patients took anterior-posterior and lateral view x-ray examination, anterior-posterior T-smart tomosynthesis scan, and computed tomography before revision surgery. As the gold standard, intraoperative pull-out tests and twisting tests were done for every patient to examine the stability of all implants. 7 orthopedic surgeons evaluated the preoperative images independently, who were divided into the senior

group (3 doctors with 6~13 years' clinical experience) and the junior group (4 doctors with 2~4 years' clinical experience). The X-rays were evaluated first, followed by computed tomography 4 weeks later, and after another 4 weeks' interval the T-smart tomosynthesis were assessed. All doctors used the same criteria for diagnosis. Diagnostic accuracy for each imaging examination was calculated by comparing with the results of intraoperative tests. The diagnostic accuracy and chi-square tests were conducted to examine the difference between the senior and junior groups for each technique.

1.3. Results

The accuracy of T-smart tomosynthesis on stability diagnosis (loosening or stable) is 82.6% for femoral stem and 84.5% for acetabular cup. The accuracy of X-ray is 44.3% for stem and 67.3% for cup, and the accuracy of CT is 39.6% for stem and 74.6% for cup. For plain X-ray, the diagnostic accuracy of the senior group is significantly higher than that of the junior group ($p < 0.05$), but no significance was found between the 2 groups for tomosynthesis and CT.

1.4. Discussion

Our research indicates that, compared with X-ray and CT, the T-smart tomosynthesis technique can greatly improve the diagnostic accuracy on stability of cementless THA components, and significantly shorten the learning curve of inexperienced surgeons. With T-smart tomosynthesis, the peri-implant trabecular bone can be clearly imaged with least metal artifacts ever. T-smart tomosynthesis is an effective and promising imaging technique for diagnosing the stability of THA components.

2. Content of the Presentation

2.1. T-smart Algorithm

Shimadzu worked on the project named as T-smart. T-smart actually is “Tomosynthesis Shimadzu Metal Artifact Reduction Technology”. Basically, the philosophy of T-smart is to divide metal image and periprosthetic bone images separately. Then, reconstructs them and finally put them together. This technology allows us to display very fine bone structures. For total hip patients, T-smart allows us to clearly display spot welding and radiolucent line around the prosthesis. Then, it allows us to evaluate the fixation stability of components (Fig.1).

Advantages of T-smart

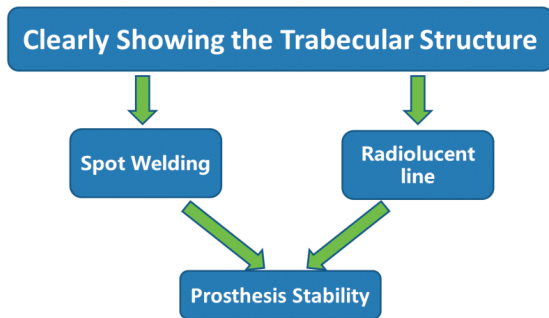


Fig. 1

2.2. Advantages: Spot Welding

On the T-smart tomosynthesis pictures, you can clearly see three to four spot weldings (Fig.2). Then, it is confirmed the stem is well fixed. I didn't do ETO. This kind of spot welding quite guided me where to put my osteotome.

Advantages : Spot Welding

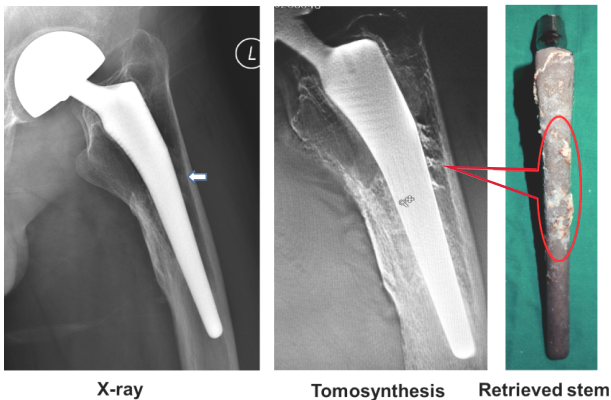


Fig. 2

2.3. Advantages: Radiolucent Line

This is also one of my patients, there is no clear spot welding and there are not so clear radiolucent

lines around the stem on X-ray. However, on tomosynthesis imaging, you see there is very fine complete radiolucent line around the stem. So, the loosening is confirmed with retrieved stem. You can see the porous coated pattern. The proximal stem was covered with a layer of fibrous tissue.

Advantages : Radiolucent Line

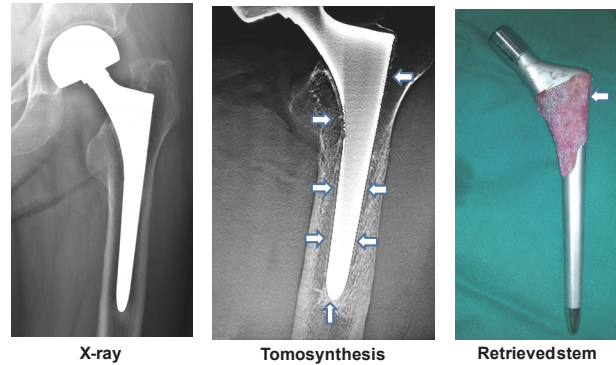


Fig. 3

2.4. Result

These are “The Diagnostic Accuracy Results” compared to X-ray or CT scan either on the stem side or acetabular side (Fig.4). Tomosynthesis provides the most accurate diagnosis, and you can see especially for the femoral stem side, the wrong diagnosis actually is as low as 3.8%.

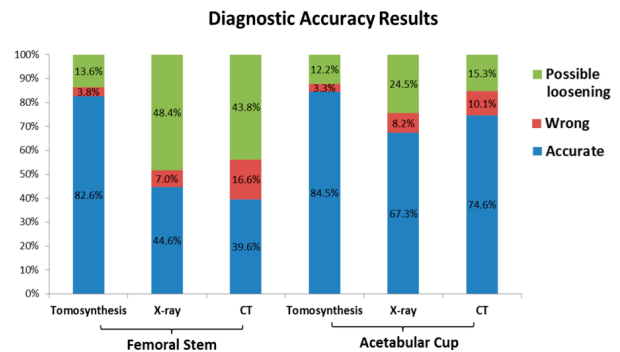


Fig. 4

These are “Sensitivity and Specificity Result for Spot Welding” (Fig.5). So, we believe with tomosynthesis imaging, it is much more accurate to observe spot welding than the other two methods.

“Influence of Clinical Experience on Diagnostic Accuracy” (Fig.6, Fig.7), with tomosynthesis imaging technology, we didn't observe that clinical experience play any important role, however with conventional CT scan and X-ray, clinical experience dose play an important role.

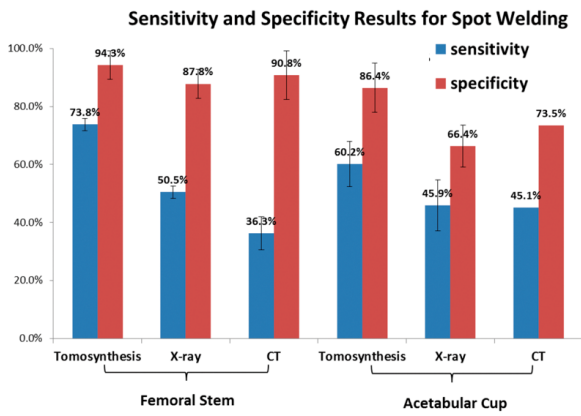


Fig. 5

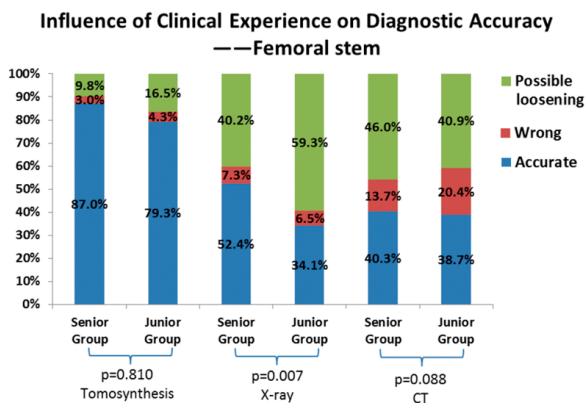


Fig. 6

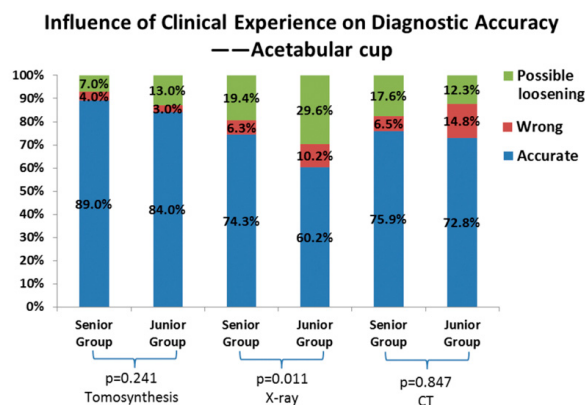


Fig. 7

2.5. Discussion

Compared to X-ray, tomosynthesis clearly displays fine bone structures especially trabecular bone and it allows us to pin-point where the spot welding is. And it's also very useful to define the radiolucent lines. So, accuracy with tomosynthesis imaging technology was improved and the learning curve was shortened. Compared to CT scans, tomosynthesis technology allows us to be exposed extremely lower levels of X-ray, and it's also very cost effective, and the image quality is very high.

We do have some limitations, with this study at that time, we didn't have CT scanner with software which allows us to reduce artifact. It is retrospective study, and the diagnostic accuracy of radiolucent line was not evaluated. However, we evaluated the diagnostic accuracy of spot welding.

2.6. Conclusion

In conclusion, we did find some strength of T-smart tomosynthesis (Fig.8). It significantly reduce the effect of artifacts, the quality of imaging is high because the spatial resolution is very high. So, clinical experience played less important role, and the diagnostic accuracy was improved.

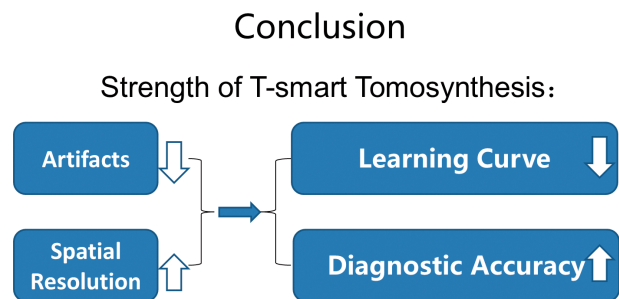


Fig. 8

3. Clinical Cases

3.1. Case 1 (Fig.9)

This is a patient of mine with periprosthetic fracture. So, preoperatively we had debate. Should we remove the stems and use longer stem to fix the fracture and achieve primary, and then long term biological fixation? We did tomosynthesis imaging and observed quite a lot spot welding around the stem. And you can see the fine trabecular structure immediately attached to the stem. Then we knew the stems were fixed and we fixed the fracture with cable and plate.

3.2. Case 2 (Fig.10)

This is another patient who took tomosynthesis imaging, which tells us where the spot welding is. Then, also it confirms this new bone immediately attached to the cup side. Then we see the cup is loosened, and the stem is well fixed. This guided us to use appropriate surgical techniques to remove the components.

3.3. Case 3 (Fig.11)

This patient complained about postoperative hip pain, 3 years after his hemi-arthroplasty. With the Tomosynthesis images, the large area of spot welding was clearly depicted, giving us confidence that the pain came from the degenerated acetabular side. Hence our treatment was to revise it into a total hip without causing too much bone loss by avoiding ETO, since T-smart effectively guided us when disrupting the bone-prosthesis in-growth sites.

3.4. Case 4 (Fig.12)

For this patient, all surgeons in our department believed that the stem was loosened by looking at the plain x-ray before surgery. However, with the T-Smart tomosynthesis, we discovered possible spot welding on the surface of the distal stem. And this was confirmed by intraoperative pull out tests and removal tests. The distal stem was firmed

fixed and could not be taken out, although the proximal sleeve was confirmed to be loosening. Finally only the proximal sleeve was revised, with the distal stem left in and well fixed.

3.5. Case 5 (Fig.13)

For this patient, the preoperative x-ray showed the stem “subsided” for more than 1 cm, with the big fissure at the metaphyseal part of the stem-bone interface, which can easily lead one to the judgment of loosening. Actually, after looking at the T-smart images, we were quite sure that the stem was well fixed, which was confirmed by the retrieved stem.

For the acetabular side, the spot welding was clearly outlined on the T-smart images, just beside a large bone cyst, which may be very confusing on x-ray. And the retrieved cup showed us the point of bone in-growth, in consistency with the T-Smart findings.

case 1

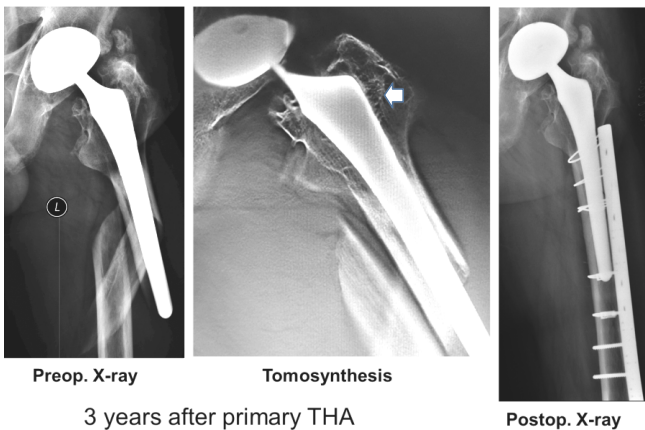


Fig. 9

case 2

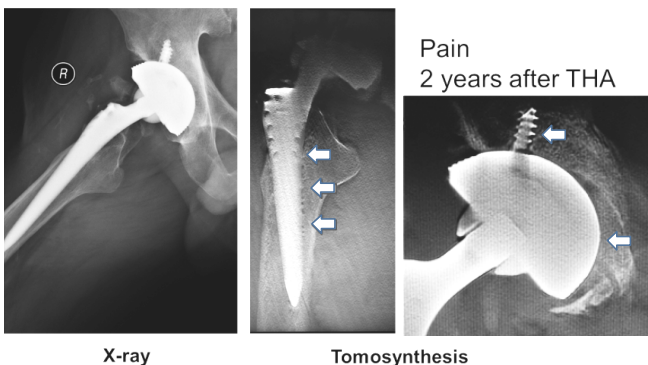
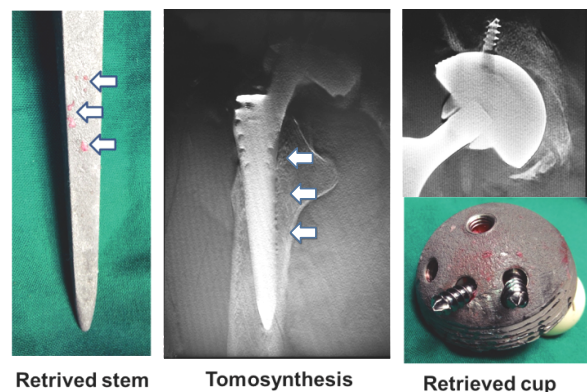


Fig. 10

case 2 stem well fixed, cup loosening



case 3

3 years after hemi-arthroplasty, stem well fixed

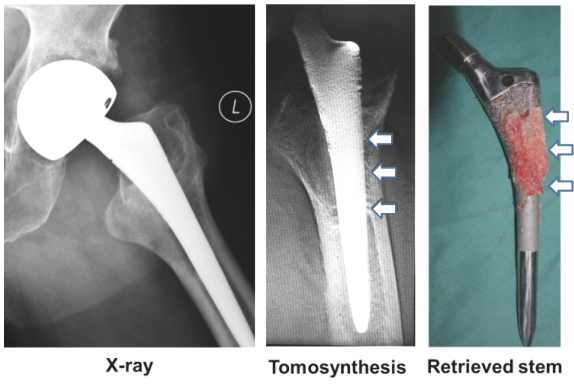


Fig. 11

case 4

3 years after revision THA, stem well fixed and not removed

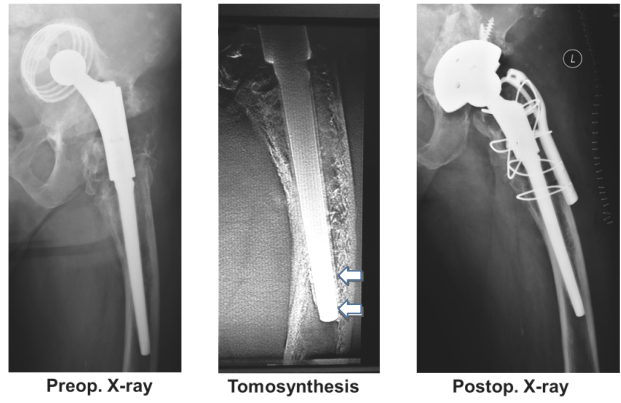


Fig. 12

case 5

Pain, 4 years after THA

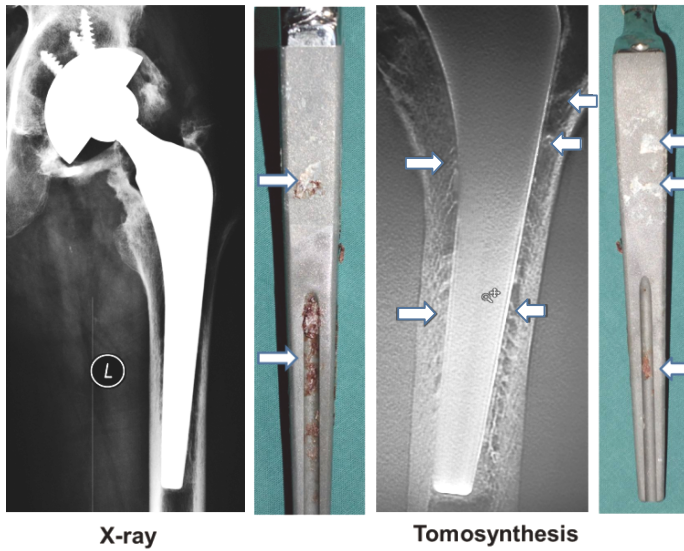


Fig. 13

case 5

