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Metal artifact reduction with Dual Energy and the SOMATOM Definition Edge

Fig 1: The BUG Hospital Tübingen is one of the major trauma centers in Southwestern Germany. In 2012 the hospital was looking for a new high end CT to replace the older system.

Abstract

Dual Energy has been one of the most important innovations in Computed Tomography in recent years and has made its path into clinical routine. With previous CT generations, it was difficult to evaluate tissue and bone structures close to metal implants such as nails, screws, and plates. With the SOMATOM Definition Edge and its Dual Energy functionality, this has now changed.

The BGU Hospital in Tübingen was one of the first customers to install the SOMATOM Definition Edge in combination with Dual Energy in order to reduce metal artifacts. This combination makes possible better evaluation of clinical cases and an earlier removal of the patients' metal implants.

Fig 2: In mid-2012, the hospital decided to go for the SOMATOM Definition Edge. The Siemens high-end single source CT is equipped with the renowned Stellar Detector technology and several more dose reduction features.

Introduction

Closely located to the University Hospital Tübingen, the BGU Hospital is one of the largest trauma hospitals in Southwestern Germany. Its portfolio mainly includes healthcare service for all kind of accidents and stretches from fractures to spine surgery and polytraumta. The radiology is being run by Prof. Claussen (Head of Radiology Department, University Hospital Tübingen and Radiology BGU Hospital) and his team. The chief radiologist of the radiology department at the BGU hospital, Dr. Luz, is an experienced user of the SOMATOM Definition Edge and its Dual Energy application monoenergetic. In the beginning of 2012, the Hospital was looking for a high-end CT system to replace their outdated previous system which had served several years.

The main criterion was that it should, on the one hand, include the latest technology in terms of dose reduction and fast iterative reconstruction. On the other hand, it should offer additional value for their specialist portfolio as a regional trauma center. Being a trauma center means that a large group of patients have to undergo CT scans more than once – for example, in follow-up scans after surgery – and that many patients receive metal implants for some weeks in order to stabilize difficult fractures or degenerated bone tissue.

Challenge

"With the technology of our previous CT system, CT staff was pessimistic most of the time," says Dr. Luz. "The metal implants caused artifacts that did not allow an exact evaluation of the surrounding tissue. This means that in order to stabilize a facture, we generally left the implants in the body too long instead of removing them too early." Every radiologist faces this issue. Metal implants such as screws, nails, or plates cause streak artifacts that derive from multiple mechanisms. One of the major effects is beam hardening. The "broad polychromatic spectrum of the x-radiation is attenuated differently, depending on the energy of the radiation, the object type, and projection direction, and consequently causes variable increases in the mean energy of the spectrum,"[1] especially in thick structures such as bones and metal.

The result are images where you see dark zones, surrounded by zones of white and even fine streaks disturbing the diagnostic image quality far away from the origin metal object. It is hard to differentiate the tissue around the metal object which stabilizes a critical, complex fracture or fixes a weakness in the spine. This is why radiologists tend to leave the metal in the body longer rather than removing it too early. The BGU hospital was therefore looking for a solution to get better image quality without putting the patients at additional risk with dose.

Fig 3: "The SOMATOM Definition Edge allows us to scan patients at an extremely low dose with excellent image quality," says Dr. Oliver Luz (Chief radiologist BGU Hospital Tübingen).

Solution

In mid-2012, the BGU Hospital Tübingen decided to go for the SOMATOM Definition Edge. This is Siemens' high-end single source CT system, which was introduced to the market at RSNA 2011 and was available for delivery by the middle of 2012. Besides the fast pitch of 1.7 that makes possible up to 230 mm/s acquisition in trauma scanning, the system comes with the newest detector technology. The Stellar Detector is the first fully integrated detector and thus results in a higher signal-to-noise ratio. The combination of Edge technology and 0.5 mm slices offers excellent image quality at reduced dose. Add SAFIRE – and the dose can be reduced by up to 60.* This is also the experience of the BGU Hospital.

"The SOMATOM Definition Edge allows us to scan at an extremely low dose with excellent image quality," says Dr. Luz. The challenge of metal artifacts is solved with the Dual Energy functionality of the system. As easy as a spiral scan, the system performs a dose optimized Dual Energy scan generating images of different keV levels. Here in Dual Energy scan mode, all dose features that apply to the system in standard scan modes come into effect. This means that Adaptive Dose Shield[2,3], CARE Dose4D, and SAFIRE[4] assist to apply only the right dose to patients without putting them at additional risk. The result of the Dual Energy scan is better image quality with higher diagnostic outcome.

* In clinical practice, the use of SAFIRE may reduce CT patient dose depending on the clinical task, patient size, anatomical location, and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose to obtain diagnostic image quality for the particular clinical task. The following test method was used to determine a 54 to 60% dose reduction when using the SAFIRE reconstruction software. Noise, CT numbers, homogeneity, low-contrast resolution and high contrast resolution were assessed in a Gammex 438 phantom. Low dose data reconstructed with SAFIRE showed the same image quality compared to full dose data based on this test. Data on file.

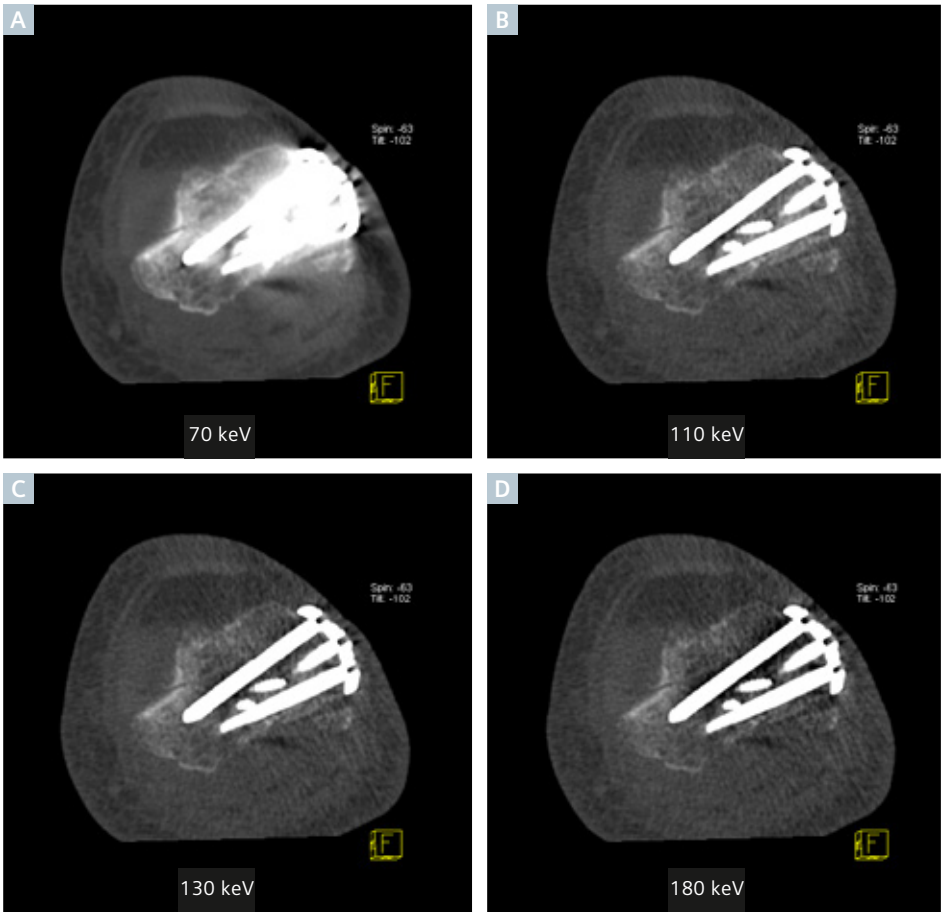

Fig 4: Without Dual Energy, the images showed metal artifacts like in the 70 keV image. Now it is possible to generate images at different keV levels with reduced metal artifacts. This offers better image quality for diagnostic evaluation.

Outcomes

The SOMATOM Definition Edge has fulfilled what the BGU hospital expected from a new high-end imaging system. With the new Stellar Detector technology, the dose in standard procedures has been lowered, and with the fast iterative reconstruction (up to 20 frames/s) the system is faster than before. For their special needs to reduce metal artifacts, Dual Energy monoenergetic imaging now enables radiologists to view the images at different keV levels and thus with higher image quality. Bone tissue around nails, screws, and plates can be better evaluated for further treatment decisions and an earlier removal of the stabilizing implant. “With the SOMATOM Definition Edge, CT staff has now become optimistic. On average, we see that we suggest to our surgeons to remove the metal implants up to three to four weeks earlier than before with our previous system,” concludes Dr. Luz. Besides the fact that it is more convenient for the patient to get the implant removed earlier, there is another advantage that comes with this. The patient can start rehab earlier, has faster recovery from the injury, and can therefore get back to work earlier. Not only the patients but also the hospital benefits from the SOMATOM Definition Edge: the new technology attracts additional patients and helps to prevent unnecessary operation procedures which might have been undertaken with the previous CT technology when metal artifacts might have caused misleading interpretation of diagnostic images.

Conclusion

The BGU Hospital Tübingen was looking for a new high-end CT system and found their wishes fulfilled in the SOMATOM Definition Edge. The new Stellar Detector technology and many of the dose reduction features have reduced radiation exposure of patients. Nevertheless, image quality has improved. Additionally, the system adds value to the clinical portfolio with its Dual Energy functionality. As easy as a spiral scan, the system generates images at different keV levels that now can show surrounding tissue even with large metal implants such as huge nails, screws, or plates. Diagnostic evaluation of images has changed from previously pessimistic evaluation to an optimistic earlier removal of metal implants, sending patients to rehab earlier than before.

References

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SOMATOM Definition Edge

Detector	Stellar Detector
Number of acquired slices	128
Number of reconstructed slices	384
Spatial resolution	0.30 mm
Rotation time	0.28 s
Temporal resolution	142 ms
Generator power	100 kW
kV steps	70, 80, 100, 120, 140 kV
Max. scan speed	230 mm/s
Table load	up to 307 kg / 676 lbs*
Gantry opening	78 cm

* Optional

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