

NeuroNews

EDUCATIONAL SUPPLEMENT



NeuroSuite: The future of image- guided neurological interventions

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NeuroNews interviewed international interventional neuroradiology thought leaders to gain their perspectives on the newly launched NeuroSuite from Philips Healthcare.

In this supplement:

- 2 NeuroSuite combats neuroradiological challenges**
- 3 AlluraClarity reduces radiation dose while maintaining image quality**
- 4 NeuroSuite experiences at the Karolinska University Hospital**
Michael Söderman
- 5 AlluraClarity and VasoCT* fundamental to neuroradiologist's practice**
Jacques Moret and Laurent Spelle
- 7 High resolution and device visualisation key features of VasoCT***
Ajay Wakhloo, Matthew Gounis and Ajit Puri
- 8 The future of neurointerventional imaging**
Thijs Grünhagen

Introduction to NeuroSuite

NeuroSuite combats neuroradiological challenges

Philips Healthcare has introduced the NeuroSuite, a new integrated solution designed to support and enhance minimally invasive image-guided neurological interventions. The new interventional X-ray solution offers more effective device guidance and placement in neuroradiological procedures.

New devices offer innovative treatment options for stroke, intracranial aneurysms, arteriovenous malformations and other cerebrovascular diseases. However, their increasingly smaller design makes them more difficult to visualise with X-ray imaging alone. This is one of the many challenges neuroradiologists face in clinical practice. To address these challenges to neurointervention, Philips has developed the NeuroSuite, and the first unit has been recently installed at the Karolinska Institute, Stockholm, Sweden. The key benefits of the NeuroSuite are grounded in its integrated features.

The NeuroSuite is built on the AlluraClarity FD20/15. This unique system configuration is the basis with its PerfectFit detector combination.

One such feature is AlluraClarity FD20/15. The X-ray solution consists of the PerfectFit 20" and 15" detector combination designed for neuroimaging.

The frontal channel detector (FD20) is larger and has a 38x30cm field of view for

advanced 3D imaging. It also allows for rotational acquisitions of the whole brain without truncation artefacts. The FD15 detector on the lateral channel gives full brain coverage for 2D acquisitions at a lower dose. The positioning of the detectors is beneficial to neuroradiologists as it gives positioning freedom and avoids collisions.

NeuroSuite offers imaging positioning and optimal imaging quality at the lowest possible radiation dose. Radiation dose with ClarityIQ, a technology which integrates real-time image noise reduction algorithms with radiation dose reduction hardware—a feature of AlluraClarity—can be reduced by as much as 73%. This technology dramatically lowers the radiation dose to patients without compromising image quality and is supported by a number of prospective clinical studies.

In neurointervention, the automatic motion compensation feature of AlluraClarity is extremely valuable when it comes to device visualisation at the base of the skull or during embolisation

of arteriovenous malformations. It compensates for patient movement and therefore minimises subtraction artefacts due to misalignment of the mask and the live image. The resulting images provide a crisp visualisation of the vascular anatomy close to bony areas as well as clear depiction of injected embolic material without disturbing motion artefacts.

Intended for image stability and enhanced patient handling, the redesigned Xper table has improved table-top stiffness which also helps prevent the appearance of artefacts. In addition to this, the NeuroSuite also includes the next generation XperCT for high resolution soft tissue visualisation.

Also a component of the suite is the 58" FlexVision XL—for sharper images. The 58" screen is a colour TFT/LCD with LED backlight and super zoom. These features are to enable resizing and zooming up to 420% with 100% sharpness.

"As of last year AlluraClarity, is sold globally and the excellent results in terms of X-ray dose reduction and image quality achieved by the first sites in Stockholm and

*VasoCT is an option of XperCT



NeuroSuite

Paris have been reproduced by physicians worldwide today,” notes Jacques Sars (marketing director, Neuroradiology, Philips Healthcare iXR).

“The NeuroSuite is designed to visualise the smallest devices and vessels while managing X-ray dose for the benefit of patients, physician and staff,” he comments.

“The treatment environment for neurointerventionalists is rapidly changing as more diseases are treated with less invasive techniques. New devices enable new treatments, but smaller and less radio-opaque devices can also present new challenges for device placement and treatment assessment. To cope with these challenges, Philips has brought a set of innovative techniques and components together in the NeuroSuite concept. All of the components are aimed at improving vessel and device visualisation in the brain, easing the workflow in the neurointerventional lab while helping physicians to manage X-ray dose effectively,” Sars states.

“An important part in the development of innovations is the collaboration with physicians from all over the globe. Having them interact with our research and development teams in defining and releasing new Live Image Guidance solutions is a key success factor,” he concludes.

AlluraClarity reduces radiation dose while maintaining image quality

In two publications by Söderman *et al*, it was found that using image noise reduction technology reduces radiation dose without affecting the image quality and working habits of the physician.

In a study published in *Radiology* in 2013 the authors set out to address that an image noise reduction algorithm for digital subtraction angiography provides a reduction in the patient’s entrance dose and maintained image quality.

Therefore, using an Allura FD20/20 biplane, two digital subtraction angiography (DSA) runs were performed. One with the default X-ray dose and reference image processing, and the other using a quarter-dose setting, including modified acquisition parameters and a real time noise reduction algorithm (ClarityIQ).

“In digital subtraction angiography, a change of technique factors combined with real time noise reduction algorithm will reduce the patient entrance dose by up to 73%, without a loss of image quality,” Söderman *et al* state.

In the second prospective study, published in 2013 in *Neuroradiology*,

the aim was to establish the impact on the physician’s working routine of using image noise reduction and system setting for neuroangiography.

In order to achieve this, Söderman and colleagues analysed radiation dose from 302 neuroprocedures using AlluraXper and 312 using AlluraClarity (614 in total) with image processing and reference system settings.

“The optimised system settings provided significant reduction in dose indicators vs. reference system settings ($p < 0.001$),” they say. The authors explain that the image-noise reduction algorithm and system settings resulted in an approximately 60% radiation dose reduction on total procedure level “without affecting the working habits of the physician”.

The two studies show that radiation dose can be reduced without suffering any loss to image quality and workflow of the neuroradiologist.

Interview: Michael Söderman

NeuroSuite merges key features for neuroradiology procedures into one system

The Karolinska University Hospital, where 300 neuroradiological procedures and around 500 angiograms are performed every year, is the world's first centre to use the NeuroSuite. Michael Söderman, associate professor, chief of Neuroangiography and Stereotaxy, Department of Neuroradiology, Karolinska University Hospital, Stockholm, Sweden, speaks to *NeuroNews* about the key components of the NeuroSuite and his experience using this all-in-one system for neuroradiological procedures.

As the world's first and currently only centre to install the NeuroSuite (June 2014), how does the system fit into your practice at the Karolinska University Hospital? Could you tell us about the key components of this technology?

We have been working with Philips in the development of the NeuroSuite for the last 10 years and it is in continuous development. The NeuroSuite that we have today has several components, which have gone through a number of technical improvements that are very important for our practice; for example, we now have the new FD20/15 AlluraClarity system which gives us better accessibility and better image quality. Specifically, the 15" detector on the lateral channel has the perfect size for the head to fit in so we can see exactly what we want. More importantly, the whole head fits into the detector without the detector being large and cumbersome.

In addition, high resolution in intracranial stenting procedures really gives us a very good view in the vessels. There is also another option which is metal reduction so we can view the stent very close to the coil mass which is important because normally we only see artefacts there.

We also have the radiation dose reduction system (AlluraClarity), which is very important in our practice. The system also allows for instant 3D reconstruction of images and also the XperCT images, which can be displayed on the monitor in a matter of seconds. With previous technologies one had to wait for the reconstruction and now—with the fast reconstruction feature—we can see the images instantly.

The NeuroSuite also features a table top that works very smoothly and a new headrest which is stable and works well.



Michael Söderman

The angulation of the headrest can be changed and it seems that the patients are comfortable with it.

In the NeuroSuite all these features have been integrated to become one system, which makes it very simple and comfortable to work with.

How can the NeuroSuite be used for stroke treatment?

We can easily do thrombectomies with the NeuroSuite using perfusion imaging and VasoCT* [features of the NeuroSuite] to find the clot. We can also import images from the CT scan and use them as a Roadmap.

You are well-known for treating arteriovenous malformations (AVMs); how would you treat a patient with an AVM using the NeuroSuite?

Everything works smoothly when treating AVMs with the NeuroSuite. The system allows us to get a good image quality and low radiation doses. Treating AVMs with Onyx (Covidien) is very common today,

and we often do a number of repeated runs. Some people might do 20, 30 or 40 runs and if you do not have a system with dose reduction you will expose the patient to significant high levels of radiation.

AVM patients sometimes are required to undergo an additional treatment and again they will be exposed to radiation. All these major radiation doses are a critical healthcare problem, which is why very low radiation doses are crucial. Having low radiation exposure also allows us to be a little bit more liberal when we decide on acquisition speed, so instead of doing low speed acquisitions of two images per second we can take up to three or four images per second with acceptable doses.

Does the NeuroSuite improve patient care?

Certainly. It provides good image quality and it is easy to handle. It also provides low radiation dose and good 3D images. All these things are very important in performing a safe procedure and helping to improve patient care.

*VasoCT is an option of XperCT

Interview: Jacques Moret and Laurent Spelle

AlluraClarity and VasoCT* fundamental to neuroradiologist's practice

At Beaujon University Hospital, Paris, France, over 600 patients are treated annually with neurointerventional procedures. Jacques Moret and Laurent Spelle from that institution speak to *NeuroNews* about how AlluraClarity and VasoCT from Philips Healthcare are fundamental in treating these patients and to their clinical practice as a whole.

They say that the advancement of AlluraClarity technology means that there are fewer radiation side-effects for patients and with ClarityIQ technology the dose has decreased by 65–70% compared to the previous AlluraClarity systems. Moret notes that VasoCT is probably the most important evolution in the last five years in the field of neuroradiology—so much so that, in the last two years, he can no longer work without it.

AlluraClarity

Moret says that, at Beaujon they use the AlluraClarity to treat many neurological conditions such as aneurysms, brain and spinal arteriovenous malformations, metastases of the spine and osteoporosis. He told *NeuroNews* that the benefit of AlluraClarity for treating these conditions is that it reduces the radiation dose to the patient whilst maintaining image quality.

“If we review the dose for the same kind of procedure we had two years ago, compared to the dose we have now, the time of exposure and the pathology are roughly the same.” Moret says, adding that dose reduction has improved outcomes because previously with lengthy procedures a lot of fluoroscopy had to be used. “There is definitely an enormous improvement regarding the dose that the patient receives during the procedure,” he says.

ClarityIQ

According to Spelle, the image quality using AlluraClarity with ClarityIQ is much better than previous systems. He explains that the motion reduction software allows for a much better depiction of the vessel. “This is because we do not see the position of the bone and the shadow of the bone on the vessel. ClarityIQ allows for better accuracy in the visualisation of the vessel inside the brain,” he continues.

In addition to his current experience



Jacques Moret

with the technology, Spelle discloses he is also conducting a study to scientifically assess ClarityIQ reduced radiation dose compared to traditional imaging (Allura Xper) and data is expected by the beginning of 2015.

Despite these advancements, the field of neuroradiology still faces challenges to clinical practice, such as visualisation at the base of the skull and treating arteriovenous malformations in the brain. According to both Moret and Spelle, AlluraClarity addresses these difficulties.

Moret explains that visualising the skull base is complex as it is a bony area and “the more bone at the base of the skull, the greater chance of artefacts in cases of patient movement.” Spelle adds that the base of the skull is always a very challenging anatomy construction because there is superimposition of the posterior saculation.

Therefore, to overcome the bone arte-

facts, physicians require greater control over this visualisation process. “The visibility of the anatomy, the material and types of treatment we use at the base of the skull have dramatically improved because of real time remasking with the AlluraClarity system,” Moret states. “We have had a tremendous improvement in visibility at the base of the skull because the bone artefacts have almost completely disappeared with AlluraClarity. This is intrinsic to the system.” In addition to this, Spelle says that with ClarityIQ the motion reduction software enables him to completely remove the skull base, which results in excellent visualisation of the vessel, especially in the cerebellum.

For the second of the challenging areas—brain arteriovenous malformation embolisation—they say that ClarityIQ has two advantages. Firstly, during a long procedure it reduces the dose delivered to the patient. Secondly, AlluraClarity provides automatic motion compensation which creates an image of higher quality, especially during injection of liquid embolic material into the nidus of the malformation. It allows for very accurate visualisation, especially checking for reflux along the microcatheter.

According to both physicians, AlluraClarity with ClarityIQ provides them and their clinical practice with greater visualisation in difficult anatomy, clearer images of vessels in the brain whilst providing a reduced radiation dose to patients and physicians.

“ VasoCT is probably the most important evolution in the last five years. In the last two years, the quality of VasoCT has become so good that it is absolutely fundamental. We cannot work without VasoCT anymore. ”

Interview: Jacques Moret and Laurent Spelle

VasoCT*

Further to the AlluraClarity system, Moret and Spelle discuss their experiences using VasoCT—a tool they both employ at their centre. Moret says that VasoCT gives them the “tremendous amount of possibilities to expand their understanding” in one of the aforementioned challenging areas—treatment of arteriovenous malformations. VasoCT, according to Moret, allows them to create a 3D Roadmap, meaning they see not only the vessels but all the surrounding brain tissue. “We can do the same with the magnetic resonance (MR) pictures. With this, there is the possibility to fuse all kinds of pictures; no matter the source of those—computed tomography (CT) or MR—we can overlay them with the 3D angiogram,” Moret explains. The implications of the VasoCT software is that, when treating arteriovenous malformations, the progression of the embolic material in the vascular bed of the malformation can be tracked to see whether it stays in the bed whilst being able to see the surrounding brain.

In terms of treating aneurysms, Spelle says that VasoCT is used in routine practice. “VasoCT is done systematically



Laurent Spelle

after the placement of a stent or flow diverter. It is performed to assess whether or not they are properly placed. Using VasoCT we have good visualisation so we can check if the device lies against the wall of the vessel and depicts embolic complications that could occur along the stent that cannot be visualised with a conventional angiogram.”

Moret states, in conjunction with Spelle’s thoughts, that: “VasoCT is probably the most important evolution in the last five years. In the last two years, the quality of VasoCT has become so good that it is absolutely fundamental. We cannot work without VasoCT anymore. VasoCT gives us precise visualisation of the relationships between the material and the vessel and this is the only way to clearly understand those relationships. Without a technology like VasoCT, there are procedures that are too dangerous to do.”

He continues by saying that without VasoCT, some endosaccular devices for aneurysm treatment could not be delivered as it is the only way to exactly

see the brain in the vessel content. “This is a great evolution [in our clinical practice] and it has become absolutely mandatory,” he adds.

Looking to the future, Moret says he sees the technology developing and “would love to be able to use the VasoCT scan as a roadmap, by overlaying the 3D picture of the vessel on live fluoroscopy”.

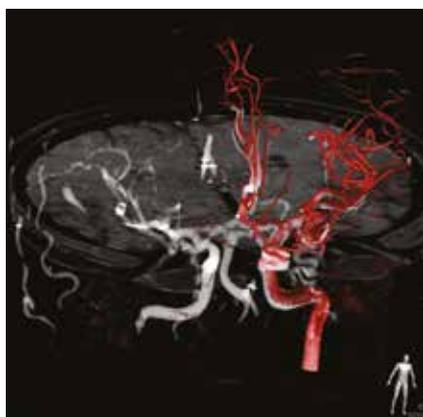
He explains that development of a “subtracted VasoCT” could be beneficial in the future. This is because when treating an aneurysm with coils, the coils can be seen on a regular angiogram. When a VasoCT, CT or XperCT is taken, artefacts may appear due to beam-hardening caused by the coils. “When we follow the patient at six months and two years post-treatment, the artefact of the coils may appear on the acquired VasoCT. We could reduce this artefact by using subtracted VasoCT.”

“In order for this to work we would acquire a VasoCT with no contrast, use it as a mask and then subtract it from VasoCT with contrast in the vessel. This means that the material which was delivered two years ago photographically disappears and gives us a better view of the underlying vessel. We know that this would be useful because we already have the 3D angiogram with subtraction, so developing a subtracted VasoCT to reduce as much as possible the artefact from the previously deposited material would be a good evolution of the technology,” Moret says.

In the meantime, he concludes, “VasoCT has become so good that it is absolutely fundamental”.

Recommended literature

■ Caroff *et al.* Role of C-arm VasoCT in the use of endovascular WEB flow disruption in intracranial aneurysm treatment. *American Journal of Neuroradiology* 2014; 35(7), 1353-1357.



3D Roadmap

“ With ClarityIQ the motion reduction software enables me to completely remove the skull base, which results in excellent visualisation of the vessel, especially in the cerebellum. ”

“ VasoCT gives us precise visualisation of the relationships between the material and the vessel and this is the only way to clearly understand those relationships. ”

*VasoCT is an option of XperCT

Interview: Ajay Wakhloo, Matthew Gounis and Ajit Puri

High resolution and device visualisation key features of VasoCT

According to physicians using VasoCT*, one of the main advantages of the technology is that, unlike conventional angiography, it has the capability to image the vasculature of the brain and implanted devices. In recent years, cerebrovascular devices have become difficult to image as their diameters have evolved and decreased. Ajay Wakhloo from University of Massachusetts Medical School (UMASS), USA, says that as minimally invasive and endovascular procedures replace open surgery in the brain there is a need to see more than black and white when imaging the brain.

At LINNC 2014 (23–25 June, Paris, France) Jacques Moret presented on imaging technology and its evolution in the field of interventional neuroradiology. He said that VasoCT, magnetic resonance (MR), computed tomography (CT) and 3D imaging can now be matched together to ensure a better view of implanted devices in the brain. He noted that intravenous injection with VasoCT and the 3D reconstruction was better than regular angiography CT. He went on to speak about the WEB device (Sequent Medical) and advised that the device should not be placed without VasoCT as “it is the only technology that allows neuroradiologists to visualise its placement in the vessels”.

In a publication from J Caroff and colleagues (*Am J Neuroradiol.* 2014 Jul;35(7):1353-7), the role of VasoCT in the use of the WEB aneurysm embolisation system was evaluated. They say that embolisation using the WEB device is promising for wide-necked aneurysms but is “barely visible” on digital subtraction angiography.

Twelve patients with 13 intracranial aneurysms were included in the study and treated with WEB. Scans were taken with digital subtraction angiography and VasoCT and reviewed by two neuroradiologists.

Caroff *et al* state that the mesh of the WEB device was well depicted “allowing a very good assessment of its deployment”. They also note that VasoCT allowed for good assessment of eventual residual blood flow inside the aneurysm or device at follow-up.

Concluding the paper, the authors say that VasoCT is an “excellent tool to assess WEB deployment and positioning”; adding that safety in using the device could be enhanced as it helps prevent possible thromboembolic events.

Further to the paper from Caroff and colleagues, Ajay Wakhloo, Matthew Gounis and Ajit Puri (all University of Massachusetts Medical School, USA) spoke to *NeuroNews* about their experiences with VasoCT and how the high contrast resolution enabled them to better visualise implanted devices. They say that, at their institution they undertake 1,000 interventional procedures per year. This

equates to 150 arteriovenous malformations, dural fistulas and acute stroke, 200 aneurysms and 600 diagnostic angiographies. They add that they use VasoCT for all their neuro patients and implement it for diagnostic and follow-up studies in approximately 20% of patients.

Wakhloo says that the challenge that neuroradiologists previously faced was

“**VasoCT is an excellent tool to assess WEB deployment and positioning.**”

visualising the vessel and the implanted device simultaneously. “How do we use the X-ray and yet see the metal materials which are so fine—they are reaching the diameter thinner than a strand of hair. In more recent times, the diameter is 10–15 microns; that is 15 thousandths of a millimetre wires. On X-ray these wires cannot be seen. Because of the fine metal structure people use CT and the wires can be seen because it has a very high contrast resolution,” he explains.

VasoCT at UMASS

Wakhloo says that Philips and UMASS have embarked on a journey to combine the CT as well as conventional angiography.

In order to achieve this, a flat panel detector was introduced to the angiography system. The flat panel detectors are based on silicon oxide detectors.

“It has enabled both modalities to work at the same time so we can have the CT images and angiography. We then combined the two and we were able to see the implants and the vasculature together,” Wakhloo explains.

“It is a very helpful tool for the surgeon nowadays to understand the details of the implants and its environment and that was not possible a few years ago.”

Research

Gounis says, in terms of translational research, he has never seen a technology that translates so rapidly. He notes that, in April 2009, they identified the problem [of device and vessel visualisation] and came up with a potential solution to acquire cone beam CT (one of the oldest forms of CT) and to do a truncated field of use at a higher magnification and to transfer every pixel (full-scale reconstruction) to preserve spatial resolution.

“We did this in models and we saw the nickel-titanium stent with 40 micron struts which typically cannot be seen under X-ray. We were able to see the device precisely *in vitro* in the model,” Gounis reports.

He explains that, in an animal study, they then investigated if they could anatomically image these devices and their apposition. They also looked at simultaneously injecting iodine to see the vessel and the relationship of the device to the vessel. “This was challenging because if you take away all the contrast of the device by injecting high doses of iodine or contrast material, then you cannot see the device. We carefully titrated the contrast and this allowed us to acquire and process the images,” says Gounis.

“We then studied this particular question in patients after we had optimised the way we acquired the images in animal models. Within six months we had acquired 60 cases using this technology which ultimately led to US Food and Drug Administration (FDA) approval. The entire translation took place over less than a year. This is remarkable in our current environment,” comments Gounis.

“It is interesting that in our study one third of our patients had a radiological finding which ultimately altered the course of their treatment.”

Clinical applications

At UMASS, intracranial vascular diseases are being treated with endovascular or minimally invasive techniques—the majority of the cases are aneurysms and arteriovenous malformations, according to Puri. He says that stents—and more recently flow divert-

ers—are used for treating aneurysms.

“When imaging flow diverters, the basic rationale is to cover a normal artery segment to another and cover the diseased segments with these stents. Flow diverters only work well if you cover and hug the vessel wall intimately. If the stent is not well opposed to the wall then you have a risk for the vessel not healing and the aneurysm not closing properly; in addition clots can form and this can cause a stroke.”

“This brings us to the problem of how to image this, and this is where VasoCT* or any cone beam CT becomes of paramount importance. With this technology, once you have implanted the device you can do the cone beam CT and you can document that you have covered the aneurysm and that the vessel is well covered and there is no malapposition.”

Puri says that if a problem occurs, they can take immediate measures such as using a balloon or using a different stent to ensure the vessel heals correctly and that thromboembolism is avoided in the future. “That is one of the major advantages of VasoCT,” he comments. “This is a perfect example of how translational research has been used in clinical practice. For all cases in which stents are implanted in the brain we use VasoCT,” he continues, adding that at follow-up, imaging can be used to document the process of aneurysm healing.

Follow-up

Quantifying what Puri explains, Gounis says that in animal models the vessels can be explanted and then paired the and the *in vivo* VasoCT can be paired to the *ex vivo* histology.

“We could not see with VasoCT a single cell layer covering but once the intimal hyperplasia was about 50 microns we could measure the tissue growth over the stent using VasoCT with histological precision. This is a validation of what is happening in reality.”

The other advantage of using VasoCT, according to Wakhloo is that image data can be acquired by injecting intravenous contrast. He explains that a venous access can be placed and contrast injected into the vein. From this the data set can be acquired. Puri says that this can be done in 20 seconds and the volume can be reconstructed in 10 seconds. He says the benefit of this is that the patient does not need to be catheterised and it can be performed as an outpatient procedure. He adds that the patient, at follow-up, can undergo the procedure and go home an hour later.

Gounis continued saying that, compared to other 3D imaging techniques, the advantages of VasoCT are its spatial resolution. “There is no other imaging technique that I am aware of that provides this level of spatial resolution. If you have a CT or MRI you acquire a series of slices and then reconstruct them into a 3D image, but the spatial resolution will not be uniform depending on how you look at it.” He gave the example of the sagittal view and how images are not very precise on that

plane. He says that with VasoCT, the dataset is isotropic so it can be viewed from any orientation at the same high resolution.

Wakhloo notes that it is also always a 3D data set which is then available on a workstation. This can be viewed at home, in a doctor’s office or during the procedure. “It is readily available and with a mouse click you can rotate then whole image, slice it in all directions. You get cross sectional imaging and three dimensional reconstructions,” he notes.

Concluding Wakhloo says: “The difference is, in previous 3D angiography we would use a catheter and inject a substantial amount of dye and the rotate the angiography equipment around the head. It was invasively acquired and the data set was on the vasculature not on the product itself. The difference using VasoCT is that you can see the implanted devices and the vasculature and this is done in a minimally invasive way.”

Recommended UMASS papers on VasoCT

- van der Marel *et al.* High-resolution optical and angiographic CT imaging of flow-diverter stents for assessment of vessel wall apposition. *Journal of NeuroInterventional Surgery* 2014, 6(Suppl 1), ppA21-A21
- van der Bom *et al.* Target delineation for radiosurgery of a small brain arteriovenous malformation using high-resolution contrast-enhanced cone beam CT. *Journal of NeuroInterventional Surgery* 2014, 6(5), ppe34-e34.
- Flood *et al.* Quantitative analysis of high-resolution, contrast-enhanced, cone-beam CT for the detection of intracranial in-stent hyperplasia. *Journal of NeuroInterventional Surgery* 2014

The future of neurointerventional imaging

By Thijs Grünhagen, senior clinical scientist at Philips Healthcare

In my role as clinical scientist, I work closely with neurointerventionalists to understand the challenges they face in their daily practice. Working closely together with our clinical partners ensures that new applications truly make a difference in the treatment of neurovascular disease. This knowledge is of great importance to us in order to properly translate clinical needs into innovative solutions. Over the years, together we have developed innovations that facilitated the work of the physicians and, ultimately, contributed to better patient care.

In the angiosuite, 2D and 3D imaging techniques are complementary in the interventional treatment of cerebrovascular diseases. Conventional angiography and fluoroscopy remain important techniques for diagnosis and treatment. Excellent image quality at low radiation dose is thus of utmost importance for accurate detection and treatment of the disease, especially with rising complexity of

procedures and with the use of devices that are increasingly difficult to visualise. Continuous improvement and refinement of these techniques are our priority and recent developments in ClarityIQ technology have contributed to reducing the X-ray dose related risk of the procedure while maintaining excellent image quality. While high-quality 2D angiography provides detailed information on vascular abnormalities and cerebral haemodynamics, 3D imaging has great value in understanding the complex anatomy of lesions and surrounding structures, as well as to assess the correct placement of devices. VasoCT has rapidly been accepted as an invaluable instrument to verify stent deployment and apposition, for instance after carotid stenting or to assess the placement of a flow diverter. XperCT (cone beam CT) has proven to be an effective means to check for bleeding before or after the procedure, without having to transfer the patient to or from a CT scanner.

The introduction of rotational imaging in the angiosuite has not only enabled the 3D depiction of anatomy and devices, but also

allowed for visualisation and quantification of functional and physiological parameters such as brain perfusion and aneurysm haemodynamics. Similarly, improvements in the image quality of XperCT will allow detection of haemorrhage with even more sensitivity and specificity. These advancements are an important step towards patient triage in the angiosuite, which can potentially save valuable time in the workup of stroke patients.

Current research has led to the development of an imaging approach to verify the result of flow diverter placement. Based on high-speed angiograms, blood flow velocities before and after placement of a diverter can be quantified and captured in the MAFA (mean aneurysm flow amplitude) indicator. Early research has shown that reduction of flow in the aneurysm as represented by the MAFA ratio is indicative of thrombosis. The possibility to quantify flow velocities perioperatively is a great example of how imaging has evolved. It may prove to be an important instrument to help clinicians in intraprocedural decision making.