White paper

Increase efficiency and improve 3D imaging workflows in neurointerventions

A workflow study at Alfried Krupp Hospital, Essen, Germany

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Executive Summary

Streamlined workflows

With ARTIS icono, improved features for innovative workflows have entered the market for neurointerventions. The ability to simultaneously rotate C-arms of a biplane system during 3D acquisitions can have a significant impact on clinical practice. With the improved stand positioning precision, previously acquired DSA images can be reused for Roadmap throughout the intervention. The new acquisition trajectory *syngo* DynaCT Sine Spin provides better image quality. Additionally, every image manipulation can be done directly from table-side to support smooth workflows.

At the Alfried Krupp Hospital in Essen, Germany, René Chapot, MD, and his team use the new angiography system in neurointerventional procedures to treat aneurysms, AVMs, and acute ischemic stroke. This workflow study investigates how they improved their clinical workflows.

- Conventional biplane systems must park the lateral plane for 3D imaging
- Twin Spin technology allows 3D imaging with both planes rotating
- Precise motors enable Roadmap use with previously acquired DSA images
- New features increase efficiency and streamlined workflows
- This study shows significantly faster workflows for 3D imaging by more than 50%

The results of the study indicate that the new features of the ARTIS icono have a vast impact on the clinical routine in Essen, more than 50% increased efficiency with Twin Spin compared to previous systems.

Thanks to the streamlined workflows for 3D imaging, the average use in specific interventions like AVM treatment has risen. Unnecessary disruptions of work steps during 3D imaging workflows were eliminated. DSA Roadmap enables working in smooth steps without unnecessary use of contrast agent and radiation dose. *syngo* DynaCT Sine Spin provides excellent soft-tissue resolution, reduces artifacts at the level of the petrous bone and brain stem, and supports procedural decision-making.

In summary, the study shows how our new solutions have an impact on clinical routine – transforming care delivery with increased efficiency and streamlined workflows.

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The Customer

Alfried Krupp Hospital, Essen

The Department of Neuroradiology at the regional hospital in Essen is well known for the treatment of AVMs and aneurysms. The department has been headed by Prof. René Chapot, MD, for more than 13 years. The hospital has 2,050 employees and about 600 beds.

The hospital's work follows the tradition of the Krupp family: the entrepreneurial spirit that has produced important progressive innovations and at the same time has always regarded service to health care as a fundamental obligation.

The Department of Neuroradiology at the Alfried Krupp Hospital offers all invasive diagnostic measures such as angiography, myelography, or the removal of tissue samples using computed tomography and ultrasound. The various intracranial or intraspinal vascular diseases, such as arteriovenous malformations (AVM) or intracranial aneurysms (vascular dilatations), and vascular stenoses, have been successfully treated in the neuroradiology department for many years and in large numbers. The treatment spectrum also includes superficial vascular malformations, acute stroke, and vertebroplasty.

René Chapot, MD, is a key opinion leader in the field of neurointerventions and well known for the development of mechanical thrombectomy in the early 2000s. He performed the first case of thromboaspiration in 1999 and supported the development of a stent retriever in 2003. In recent years he has led the field of AVM treatment evolving the pressure cooker technique and sheeping technique. Since several years, he is hosting a conference in Essen, the Advanced Live Interventional Course of Essen (ALICE). The course combines live cases, presentations, and discussions with a special focus on AVM embolization from the veins.

The Challenge

Three-dimensional imaging workflow

Intraprocedural 3D imaging is key for procedural success and consequently for patient outcomes. The capabilities of 3D imaging in the interventional suite have improved over the last decade. But still, challenges remain with conventional systems.

- A rising number of complex procedures
- Inefficient workflows for 3D imaging
- Artifacts decrease image quality of cone-beam CT

The number of endovascular procedures is steadily rising. Especially complex procedures create the need for improved workflows and supporting features. Three-dimensional acquisitions, like cone-beam-CT (*syngo* DynaCT) or digital subtraction angiography (*syngo* Dyna3D), are becoming more and more common in everyday clinical practice and can help to make procedures faster and safer [1].

syngo Dyna3D images can provide better visualization of complex structures and therefore improve navigation capabilities but also enhance understanding of blood flow, for instance in flow-guided embolization procedures. Additionally, several studies have shown that the use of *syngo* Dyna3D can lead to a reduction in X-ray dose [2][3][4].

Until recently, mechanical constraints made it necessary to park and return the lateral plane of every biplane angiographic system to perform three-dimensional imaging. This process can be tedious and time-consuming and impedes a streamlined workflow for 3D imaging. Additionally, the freedom to position anesthesia devices is limited due to the space needed for the lateral plane. Especially in time-crucial procedures like the treatment of ischemic stroke, these workflow interruptions can cost valuable time. But also longer interventions like coiling of aneurysms or embolization of AVM, require seamless workflows without unnecessary interruptions.

Often a physician needs to revert back to previous angulations of the C-arm. Using a conventional system, this is often possible. However, this feature is not part of the DSA Roadmap workflow, meaning that a DSA image cannot be used for Roadmap creation if the system has been moved after a corresponding DSA acquisition. Hence, a new vessel map with additional radiation exposure and contrast media has to be created.

Mechanical constraints make it impossible to reposition the C-arms precisely enough in the exact prior working position of the related DSA scene.

Cone-beam CT enables postprocedural evaluation and identifying complications such as intracranial bleeds. Often conventional systems provide images with artifacts especially in the basal part of the brain (e.g., petrous bone) and close to the skull. Therefore, a sufficient clinical evaluation needed for treatment decisions may not be possible in every case. In these cases, the patient has to be transferred to a CT.

Conventional systems need 20 seconds to acquire a high-quality low-contrast image of the brain.

One reason for this is the slow detector readout speed. Another is the mechanical constraints of the motors and gears. Hence, respiratory standstills are often necessary to avoid motion artifacts.

In summary, various challenges can arise during 3D workflows. Those challenges can have an impact on the daily routine workflows of physicians, and in combination, the effect can be even worse.

The Solution

Streamlined 3D workflows are key to improve procedural success.

With ARTIS icono workflows in the angio suite become faster and smoother thanks to several new features. One of them is called Twin Spin: the simultaneous movement of both C-arms during 3D acquisition. For the first time, it is no longer necessary to park and return the lateral plane.

- No need to park and return the lateral plane during 3D imaging
- System repositioning more precise and integrated into DSA Roadmap workflow
- *syngo* DynaCT Sine Spin technology for improved intracranial 3D imaging owing to new acquisition trajectories

With the new Twin Spin technology both planes move simultaneously during 3D acquisition thanks to mechanical improvements. It is no longer necessary to park and return the lateral plane. These additional work steps may have sometimes prevented physicians from performing 3D acquisitions.

Therefore, the ability to seamlessly switch between 2D and 3D imaging can improve workflow and speed up interventions, but could also facilitate the use of 3D acquisitions. Both planes can be used for isocentering, diminishing this to only one step without any additional movements. Therefore, finding the right position for 3D acquisition is easier and faster.

With ARTIS icono, the DSA Roadmap can be created from any previously acquired DSA scene. This is made possible by the sub-mm repositioning precision required to use a DSA image as a vessel map for Roadmap even after system movement. With the activation of DSA Roadmap, the Automap feature repositions the system automatically upon user request (joystick deflection) without selecting the Automap function explicitly. This omits regeneration of a new vessel map and therefore saves not only time but also radiation dose and contrast media. Mask generation is also omitted in subtracted fluoro mode, also contributing to dose and contrast media savings. Thus, the usability of DSA Roadmap has been enhanced by eliminating the restriction that a system movement invalidates a DSA scene for later use for DSA Roadmap.

In addition, all functions for viewing and manipulating 3D images can also be operated and executed directly from the tableside, for example to plan and evaluate different treatment strategies.

Furthermore, with the new OPTIQ image chain, which is based on a contrast-to-noise driven exposure control, the image quality of Roadmap has been increased thanks to improved algorithms.[1]

Thanks to a new acquisition trajectory called *syngo* DynaCT Sine Spin for intracranial cone-beam CT (CBCT), artifacts in the basal parts, especially near the posterior fossa and brain stem, are reduced to a clinically irrelevant level. This is achieved by double-oblique angulations during the CBCT acquisition. This potentially enables new workflows, for instance in the treatment of acute ischemic stroke. A transfer to CT may no longer be necessary.

For the ideal soft-tissue resolution and image quality, conventional systems[2] need 20 seconds or more. ARTIS icono can acquire 3D images with excellent soft tissue resolution in as few as 7 seconds with the same amount of projections and radiation dose. This has been achieved by the extremely fast readout speed of the new detectors and mechanics.

With our fastest cbct, not only does workflow speed up, but motion artifacts are reduced to a minimum. The acquisition time is reduced by up to 60% for high-contrast 3D images. With the new *syngo* DynaCT High Speed cone-beam CT imaging, it is possible in less than three seconds; 3D *syngo* DynaCT imaging needs only 4 seconds for each run. Here the system moves at a speed of up to 100°/s. This results in sharper images with fewer motion artifacts but also faster workflows. Thanks to the high-performance, state-of-the-art computers for reconstruction, the time until the images are visible is reduced – which also contributes to a smooth workflow.

All these new features have been developed to streamline workflows, increase efficacy, and transform care delivery in institutions around the globe.

[1] *For more information regarding OPTIQ, see our white paper about our new image chain.*
[2] *e.g.: Artis zee, Artis Q*

Material & Methods

How to investigate the advantages

Several scientific publications cite the impact of pre-, intra-, and postprocedural three-dimensional imaging [1][2][3][4]. Common sense dictates that these imaging techniques enable safer navigation and reduced radiation dose compared to 2D imaging alone.

- Evaluating the impact of new technologies on clinical workflows
- A workflow study was performed in February 2020 in Essen, Germany
- More than twenty different 3D imaging workflows were observed

To evaluate the impact of the new Twin Spin technology on everyday clinical routine, this study was performed in February 2020 at Alfried Krupp Hospital in Essen, Germany. The ARTIS icono biplane system had been installed in February 2019 as the first system worldwide and workflows have consolidated and established over one year of clinical routine. User opinions are based on one year of experience with ARTIS icono.

To quantify and compare the advantages, the 3D imaging workflows were also measured on a previous generation biplane system. All in all, 15 Dyna3Ds were measured on the ARTIS icono and 7 on the Artis zee system. Per patient, an average of 2.1 3D acquisitions on the ARTIS icono and 1.4 3D acquisitions on the Artis zee system were performed. Procedures included interventional treatment of AVMs (9 on ARTIS icono) and aneurysms (6 on ARTIS icono, 7 on Artis zee).

Every 3D imaging workflow measured was divided into different work steps as follows:
The time started when the specific imaging protocol was chosen. The next time point was the start of isocentering and the beginning of the test run. The test run requires 12 seconds on the ARTIS icono and must be performed in every 3D protocol. The test run with Artis zee takes about 15 seconds and the acquisition runs are slower at 6 seconds for each DSA run, adding up to 18 seconds compared to 12 seconds with the ARTIS icono.

All in all, the time for the whole 3D workflow was recorded, from the beginning (choosing a protocol) until the end – either being in the next working position or finishing the procedure. Statements regarding the use of the system were collected. A total of 22 3D workflows were observed and times measured.

The focus of the study includes the Twin Spin and general workflow aspects. There were no measurements made for Automap. An investigation on the image quality of the *syngo* DynaCT Sine Spin and faster 3Ds is being developed in parallel.

The Results

Workflow study shows advantages

At the Alfried Krupp Hospital in Essen, the Department of Neuroradiology has been working with the ARTIS icono for more than one year. The results of this workflow study are presented in the following.

- Increased efficiency by more than 50 percent
- No additional contrast medium and radiation dose when using Automap
- *syngo* DynaCT Sine Spin technology used at any time when follow-up imaging was needed

The results of the study show that inefficient workflow steps are eliminated. The time needed to park and return the lateral plane is eliminated thanks to the new Twin Spin technology. The average time for a Dyna3D with the ARTIS icono was 56 seconds and 123 seconds with the Artis zee.

The protocols show that in every procedure when the DSA Roadmap with the integrated Automap functionality was used, no additional contrast media or acquisition was needed.

When follow-up CBCT imaging after a procedure was needed, the new *syngo* DynaCT Sine Spin technology was used instead, in every single case. Furthermore, in no reported case was the diagnosis affected by insufficient image quality or artifacts, even in the basal part of the brain.

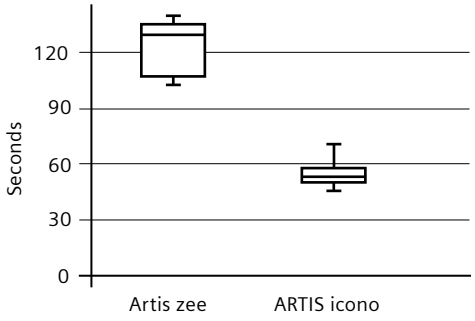
No complications, collisions with anesthesia or other equipment were reported for either system during parking or returning. In AVM procedures, the neuroradiologists in Essen use more *syngo* Dyna3Ds with the ARTIS icono than with the conventional system. On average, they perform three 3D acquisitions compared to a maximum of one on Artis zee, including two *syngo* Dyna3Ds and a follow-up *syngo* DynaCT Sine Spin acquisition.

A summary of the improved workflow featuring the averaged time for each work step is presented in the following table.

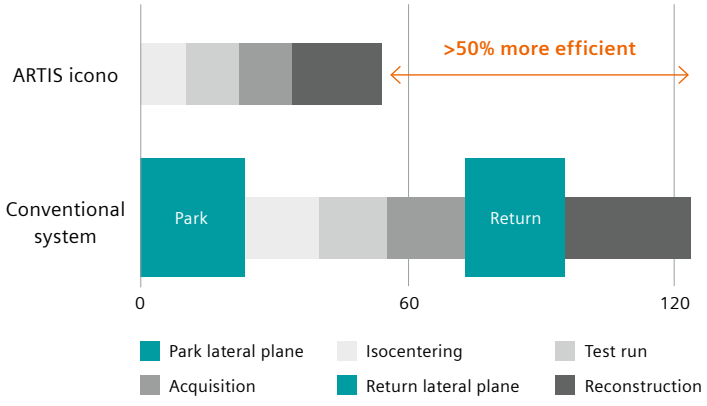
Measurements:

Reconstructions	ARTIS icono Dyna3D	Artis zee Dyna3D
Number (n):	**15**	**7**
Mean (s):	**56**	**123**
Median (s):	**55**	**130**
Minimum (s):	**48**	**104**
Maximum (s):	**71**	**140**
Std. Dev. (s):	**6**	**15**

Dyna3D Workflow



Dyna3D Workflow comparison



Discussion

Implications beyond time savings

The results of our study show the huge impact of the newest technologies on everyday clinical routine and its workflows. With the new Twin Spin technology, 3D workflows are streamlined and faster, with more than 50% increased efficiency compared to previous systems. In Essen, the workflows on the conventional system are already streamlined to a very good level. For example, anesthesia is positioned at the foot end so that collisions with the lateral plane during parking are avoided upfront. In many other hospitals around the world, anesthesia is positioned at the head end, making collisions during parking or returning more likely with conventional systems. Therefore, it can be assumed that the results from Essen indicate the bare minimum of possible workflow improvements.

Procedure time is important in time-crucial interventions like mechanical thrombectomy – therefore, small reductions in time can save viable penumbral tissue and may result in a lower rate of recurrence. In long AVM procedures, time savings mean workflow improvements and increased efficacy – also having an impact on the daily routine. In other institutions, the effect could have an even greater impact.

In AVM cases, on average three 3D acquisitions were performed with ARTIS icono. The first *syngo* Dyna3D is used for navigation purposes and the second one to evaluate the arterial inflow and the venous drainage of the malformation. A third 3D DSA can help to control the embolization process. To enable a smooth workflow during analyzing those complex structures, every image assessment and manipulation (rotation, zoom etc.) can be done directly from table-side. This leads to a better understanding of the complex vessel structure and therefore better navigation. Procedures can be done more precisely with the potential to lower the rates of non-target embolization and improve patient outcomes.

Interviews with physicians and nurses using the new system validate the clear impact on daily practices. Anesthetists appreciate the increased space around the system and that movements are more projectable regarding the removed system movements for parking and returning during an intervention. Additionally, respiratory standstills are not necessarily required, which can have an impact on the radiation dose to anesthetists.

Due to the precise system movements and the ability to choose any acquired DSA image, the system moves into this position with Automap. In all observed cases, it was possible to use previously acquired DSA scenes for an OPTIQ Roadmap. Therefore, the standard amount of contrast agent for creating a new vessel map, and the additional radiation dose was saved. All in all, this feature holds vast potential for improved and streamlined workflows, especially compared to conventional systems.

The exact quantitative influence of this technique on dose, contrast agent application, and time will be investigated in further studies.

The experience in Essen shows, that after the intervention a post-procedural cone-beam CT can be performed to rule out intracranial bleeds and other complications. Thanks to the fast 3D acquisitions, respiratory standstills to reduce motion artifacts can be avoided – resulting in a smoother workflow. Less communication between neuroradiologists and anesthetists is needed, resulting in improved efficiency. The improved quality of the *syngo* DynaCT Sine Spin due to the new acquisition trajectory has the potential to enable and support new workflows. As other studies have shown, especially the possibility to treat ischemic stroke directly in the angio suite and avoid the transfer from/to CT holds huge potential for time savings and patient outcome [5][6][7]. As indicated, in Essen the new technology is used regularly in every case where follow-up imaging, e.g., bleeding visualization is needed.

Conclusion

The results indicate the potential to reduced procedure times due to streamlined workflows. Especially in time-crucial procedures like mechanical thrombectomy, smooth workflows are key to procedural success. Additionally, the use of DSA Roadmap holds vast potential for additional dose savings. Combined with the facilitated use of *syngo* Dyna3D, radiation dose may be reduced because the number of required additional exposures can be reduced [1][3][4].

The new acquisition trajectory of *syngo* DynaCT Sine Spin enables homogenous soft-tissue resolution in basal parts of the brain to support follow-up imaging and new workflows for the treatment of acute ischemic stroke. All in all, the new features of the ARTIS icono transform care delivery in the Alfried Krupp Hospital Essen and could soon also improve clinical workflows and operational efficiency in your hospital.

References with key statement

[1] **Rooji et al. (2008) 3D Rotational Angiography: The New Gold Standard in the Detection of Additional Intracranial Aneurysms. AJNR Am J Neuroradiol 29:976–79.**
3DRA depicts considerably more small (3 mm) additional aneurysms than DSA. In selected patients, accurate detection of these aneurysms may have consequences for the choice of treatment technique, and the **frequency and duration of imaging** follow-up.

[2] **Guberina et al. (2016) Dose comparison of classical 2-plane DSA and 3D rotational angiography for the assessment of intracranial aneurysms. Neuroradiology. 58(7):673–8.**
Three-dimensional rotational angiography **clearly reduces radiation doses** compared to the classical 2-plane technique. Replacement of additional 2-plane DSA projections with 3D rotational angiography will lead to a **remarkable decrease in patient radiation dose**, without loss of image quality. Thus, we recommend the routine application of 3D rotational angiography, in particular for diagnostic assessment of aneurysm morphology.

[3] **Abe et al. (2002) Clinical Benefits of Rotational 3D Angiography in Endovascular Treatment of Ruptured Cerebral Aneurysm. AJNR Am J Neuroradiol 23:686–688.**
Three-dimensional DSA allows the acquisition of high-quality 3D images of cerebral arteries and also allows observation and analysis from multiple directions to determine the appropriate working projection for embolization. **Three-dimensional DSA is essential for optimal diagnosis and embolization** of cerebral aneurysms and can reduce the number of exposures.

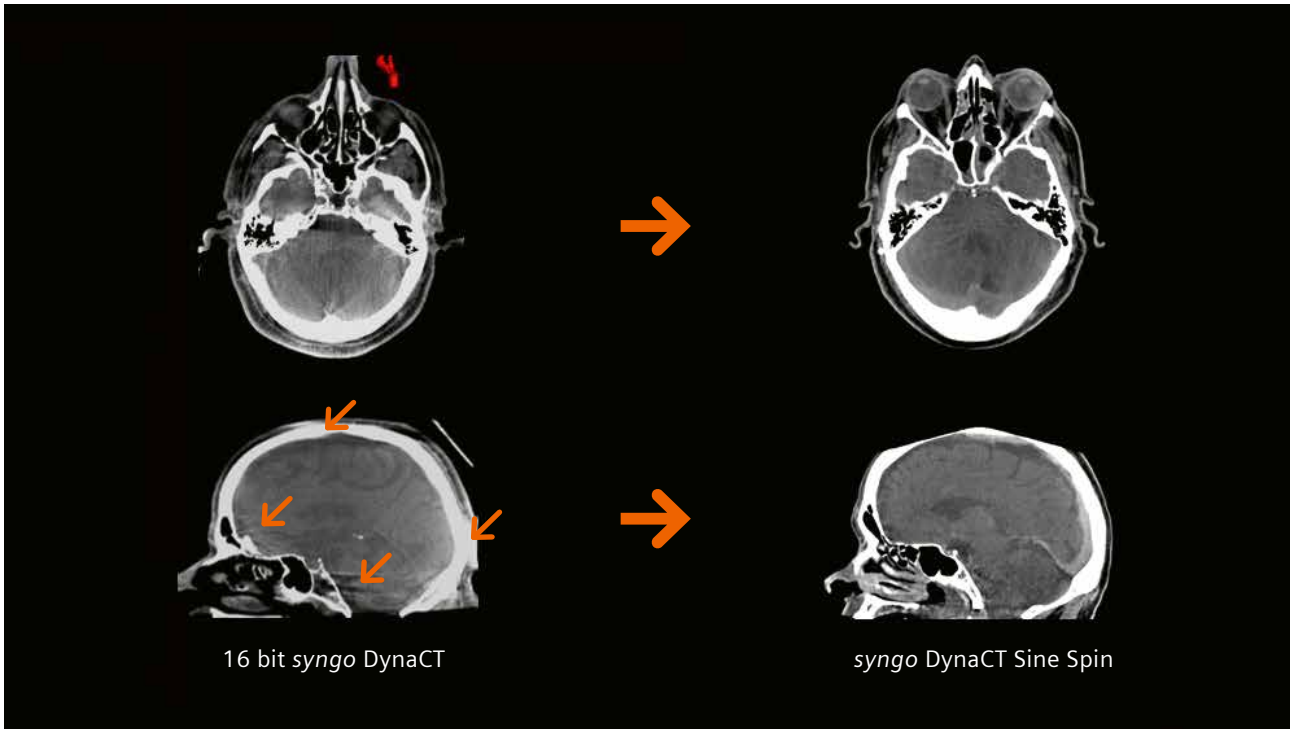
[4] **Tanigawa et al. (2002) Reduction of X-ray dose in endovascular treatment of cerebral aneurysm using 3D-DSA. Japanese Journal of Clinical Radiology vol. 47 issue 11 p. 1559–1564.**
Based on an experimental study of the measurements with head phantom by radiophotoluminescent glasses, a 33 percent reduction of X-ray dose was simulated on occipital skin by using 3D-DSA. In this report, we emphasized that the benefits of Dyna3D were not only for the neuro-interventional procedures but also for help in the **reduction of skin radiation dose.**

[5] **Psychogios et al. (2017) One-Stop Management of Acute Stroke Patients Minimizing Door-to-Reperfusion Times. Stroke. 2017 Nov;48(11):3152–3155.**
Time from admission to groin puncture was 20.5 minutes. Compared with 44 patients imaged with multidetector CT in the first 6 months of 2016, door-to-groin times were significantly reduced In this small series, a one-stop management protocol of selected stroke patients using the latest generation flat detector CT led to a **significant reduction of intrahospital times.**

[6] **Brehm et al. (2019) One-Stop management with Perfusion for transfer stroke patients due to a large-vessel occlusion – Feasibility and effects on in-hospital times. AJNR Am J Neuroradiol. 40(8):1330–1334.**
The median time from symptom onset to admission was 241 minutes. Median door-to-groin time was 24 minutes. Compared with 23 transfer patients imaged with multidetector CT, it was reduced significantly (24 minutes; 95% CI, 19–37 minutes, versus 53 minutes; 95% CI, 44–66 minutes; P < .001). Safety parameters were comparable between groups. In this small series, one-stop management with perfusion led to a significant **reduction of in-hospital times** compared with our previous workflow.

[7] **Psychogios et al. (2019) One-Stop Management of 230 Consecutive Acute Stroke Patients: Report of Procedural Times and Clinical Outcome. J Clin Med. 11;8(12).**
Two-hundred-thirty consecutive adults with suspected acute stroke presenting within 6 h after symptom onset with a moderate to severe National Institutes of Health Stroke Scale (≥10 in 2016; ≥7 since January 2017) were directly transported to the angiography suite by bypassing multidetector CT (MDCT). The **rate of good functional outcome** was significantly better in the one-stop management group (p = 0.029).

***syngo* DynaCT Sine Spin: Clinical images (Alfried Krupp Hospital Essen, Germany)**



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