

# Advanced Imaging for Interventional Neurosurgery



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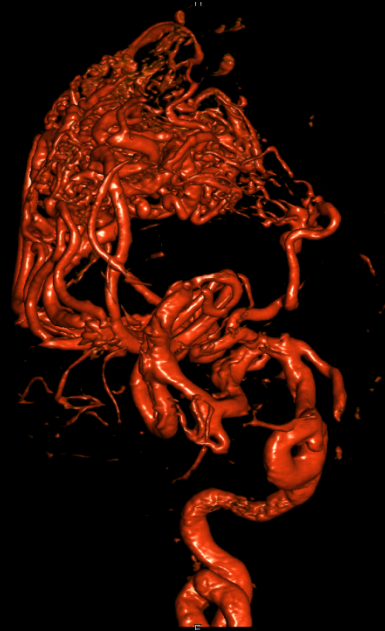
1. Introduction to neurovascular treatment indications
2. Scan and injection protocols for 3D DSA and DynaCT
3. Reconstruction parameter and secondary reconstruction
4. Tools in *syngo* InSpace and the 3D card for advanced postprocessing
5. Introduction to *syngo* iFlow and *syngo* Virtual Stent

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1. Arterial Venous Malformations (AVM)
2. Subarachnoid Hemorrhage (SAH)
3. Stroke
4. Carotid Stenosis
5. Stent assisted aneurysm coiling

# Arterial Venus Malformations (AVM)

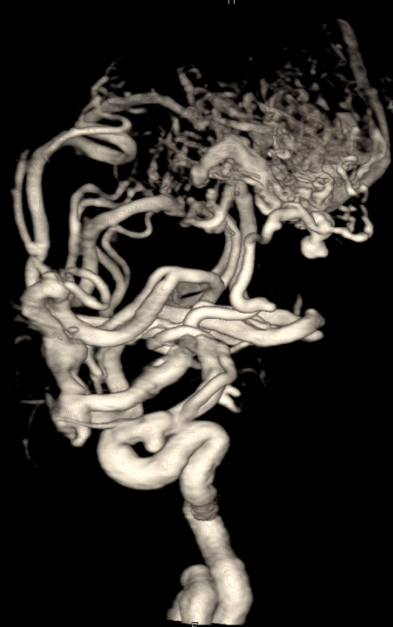
AP and lateral  
VRT  
reconstruction  
showing massive  
right AVM



SHADE/SURF  
A  
LAO/RAO  
0  
CRAN/CAUD  
0

A

B 100 W 106  
O 80 C 215

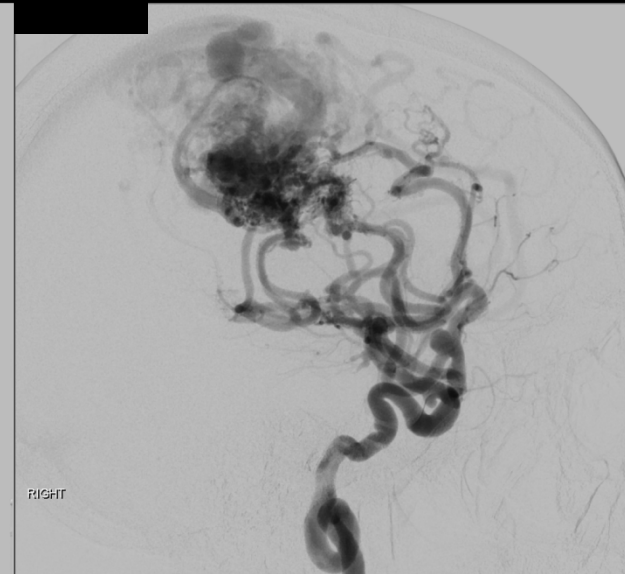


SHADE/SURF  
A  
LAO/RAO  
62  
CRAN/CAUD  
4

AL

B 100 W 259  
O 80 C 542

2D DSA AP and  
lat of massive  
right AVM



Status after endovascular Onyx embolization  
and surgical removal of AVM



# Subarachnoid Hemorrhage (SAH)

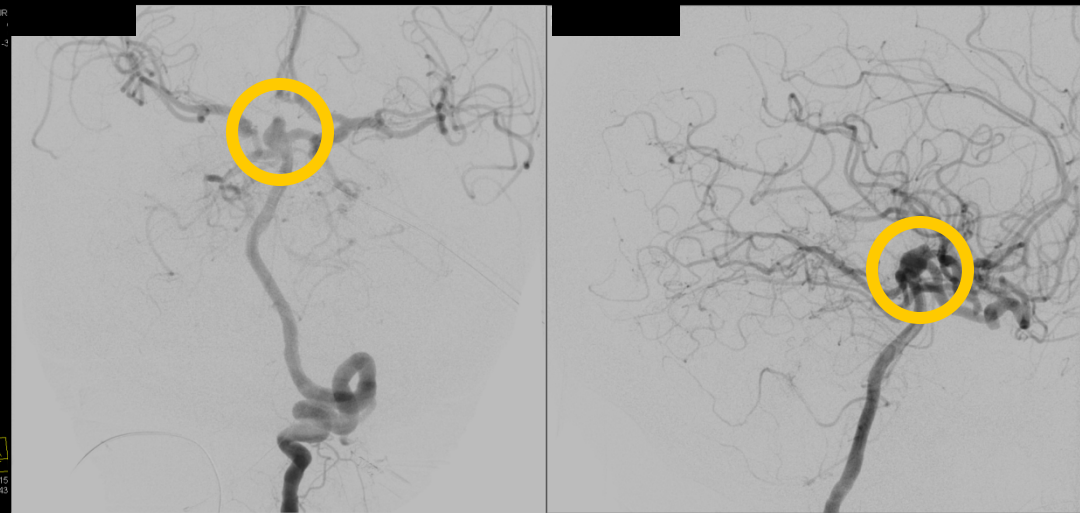
nCT  
demonstrating  
SAH



3D DSA  
showing  
basilar tip  
aneurysm



2D DSA before aneurysm coiling

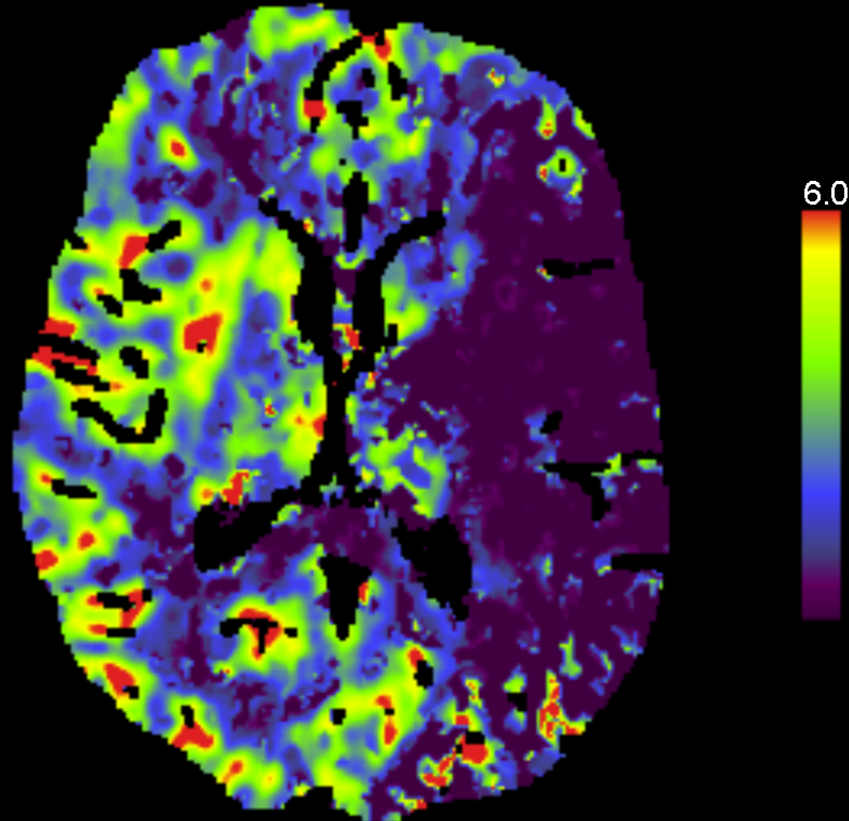


## AP and lateral 2D DSA view of coiled basilar tip aneurysm





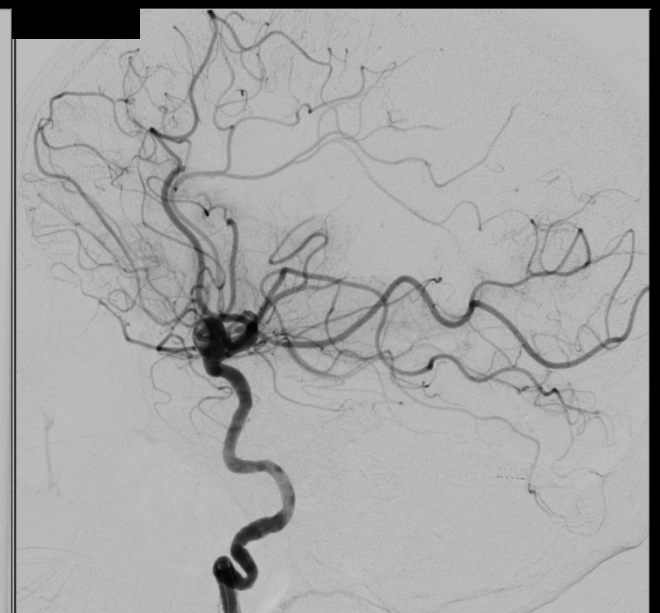
CT Perfusion (CBV)  
demonstrating left  
MCA artifact



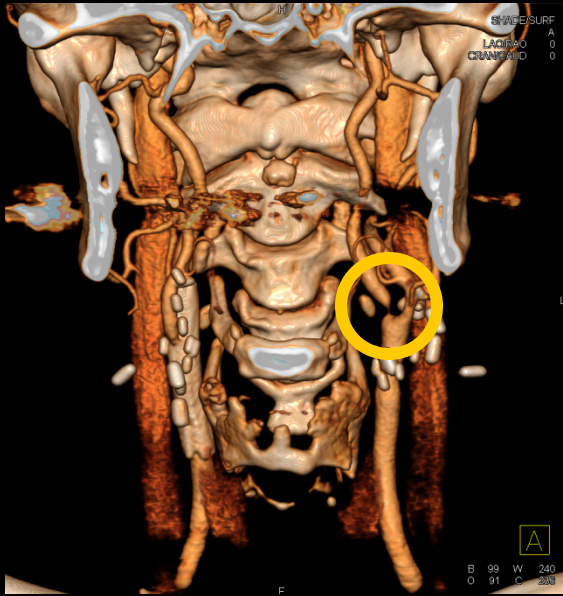
Biplane DSA showing  
occlusion of left MCA



After mechanical  
thrombolysis  
treatment showing left  
ICA aneurysm



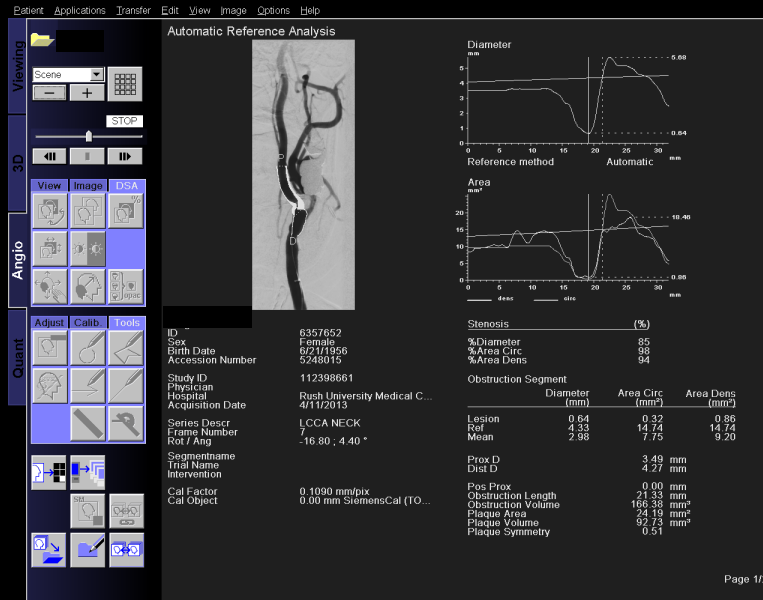
Pre-CTA of left internal carotid artery stenosis



DSA run prior to stent placement



Evaluation of stenosis using Quant



DSA run post stent



# Stent/ Coiling of Aneurysm

3D DSA showing  
left  
ACA\* aneurysm

Post stent  
placement

Post stent  
placement and  
aneurysm coiling



\* ACA: anterior communicating artery

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## 3D DSA protocols and indication

- 5sDSA: aneurysm, intracranial stenosis
- 10sDSA: AVM, tumor

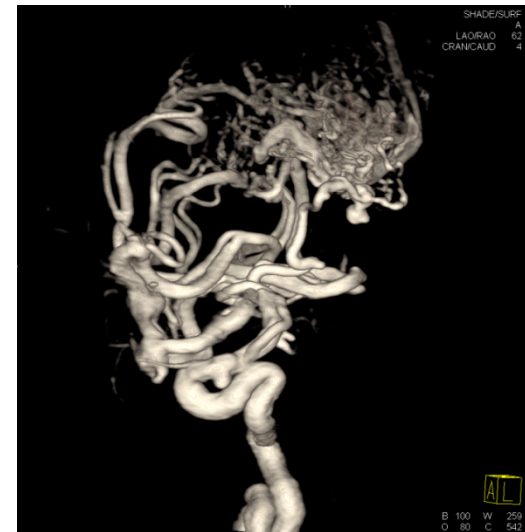
## Injection Protocol for 5sDSA:

- Flow rate: 3cc/ sec.
- Total volume: 21cc
- X-ray delay: 2 sec
- Contrast dilution: Full strength

## Injection protocol for 10sDSA:

- Flow rate: 3cc/ sec.
- Total volume: 36cc
- X-ray delay: 2 sec
- Contrast dilution: Full strength

**Total volume: Flow rate x (run time + X-ray delay)**



## Used DynaCT protocols and indication

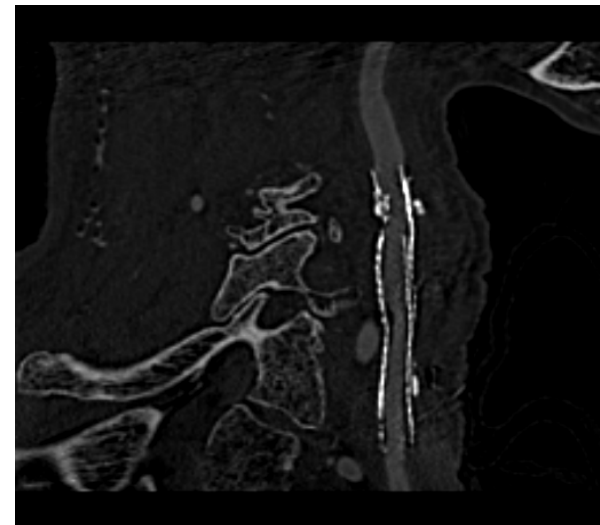
- 20sDR (70kV): bleed
- 20sDR (109kV, reduces metal artifacts): stent follow-up

## Injection Protocol for 20sDR Intrastent:

- Flow rate: 2cc/sec
- Total volume: 40cc
- X-ray delay: 2sec
- Contrast dilution: 20% (20cc contrast, 80cc saline)

## Injection protocol for ivDynaCT:

- Flow rate: 4cc/sec
- Total volume: 80cc
- X-ray delay: 13sec
- Contrast dilution: full strength



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# Reconstruction parameter I

Reconstruction	Numeric VOI
Preset:	
Modified "Angio" <input type="button" value="v"/>	
VOI Size: Manual <input type="button" value="v"/>	
Slice Matrix: 512 x 512 <input type="button" value="v"/>	
Kernel Type: EE <input type="button" value="v"/>	
Image Characteristics: Smooth <input type="button" value="v"/>	
Reconstruction Mode:	
Sub with MoCo <input type="button" value="v"/>	
Viewing Preset:	
AutoVasc <input type="button" value="v"/>	
Series Description:	
Angio	
Sub MoCo EE Smooth [InSpace3D]	

## Preset:

- Defines all following parameters, specific for one application, e.g. DynaCT Head

## VOI Size:

- Defines the size of the reconstruction
- Options: Small, medium, full

## Slice Matrix:

- Should always be 512x512 for best resolution

## Kernel Type:

- EE: Edge Enhancement, for 3D DSA only
- HU: Hounsfield Unit, for DynaCT's

## Image Characteristics:

- Similar to kernel in CT
- Options: very smooth, smooth, normal, sharp, auto
- If 3D DSA images are very noisy, use *smooth*
- For DynaCT use *normal*
- For stent visualization use *sharp*
- *Auto* often defaults on sharp

## Reconstruction parameter II

Reconstruction	Numeric VOI
Preset:	Modified "Angio" <input type="button" value="v"/>
VOI Size:	Manual <input type="button" value="v"/>
Slice Matrix:	512 x 512 <input type="button" value="v"/>
Kernel Type:	EE <input type="button" value="v"/>
Image Characteristics:	Smooth <input type="button" value="v"/>
Reconstruction Mode:	Sub with MoCo <input type="button" value="v"/>
Viewing Preset:	AutoVasc <input type="button" value="v"/>
Series Description:	Angio
Sub MoCo EE Smooth [InSpace3D]	

### Reconstruction mode:

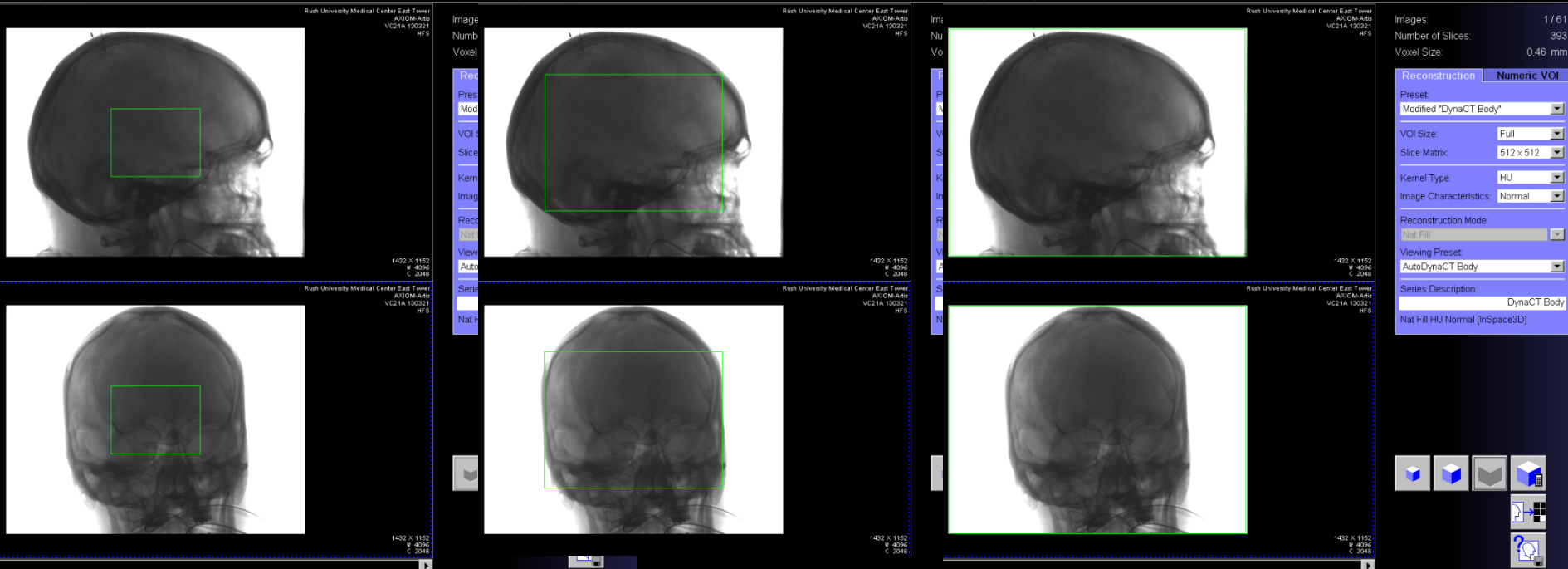
- Options: Sub, NatFill, NatMask, Sub with MoCo, Dual Volume, Dual Volume with MoCo
- *Sub (with MoCo)*: Use for all 3D DSA
- *Dual Volume (with MoCo)*: Use for 3D DSA with metal implants, e.g. coils, clips to visualize metal in a different color
- *NatMask*: Use for 3D DSA to reconstruct only the non-contrast mask run
- *NatFill*: Use for 3D DSA to reconstruct CT like images

### Viewing Preset:

- Defines how the reconstruction will be shown in InSpace, e.g. Golden for 3D DSA

### Series Description:

- Gives the reconstruction a name to be easily identified in the Patient Browser



Small VOI

Medium VOI

Large VOI

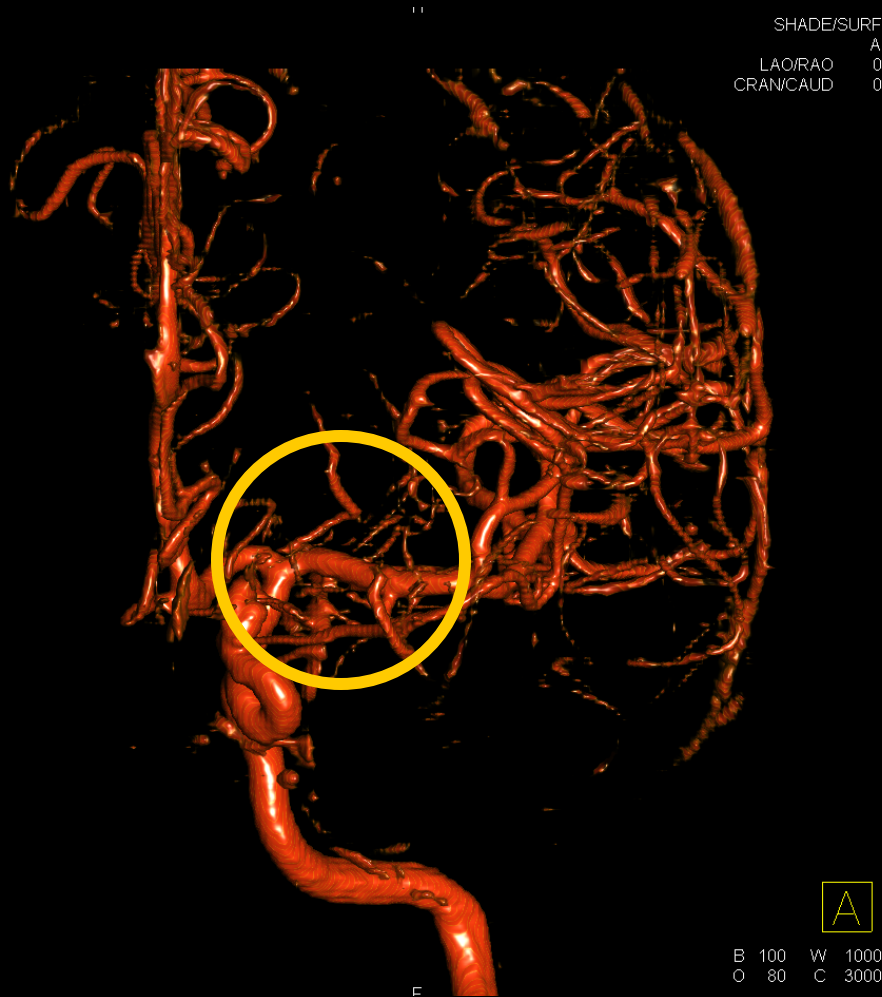
Small VOI: For best resolution, e.g. stent, small vessels, bony structures

Medium VOI: Standard for 3D DSA

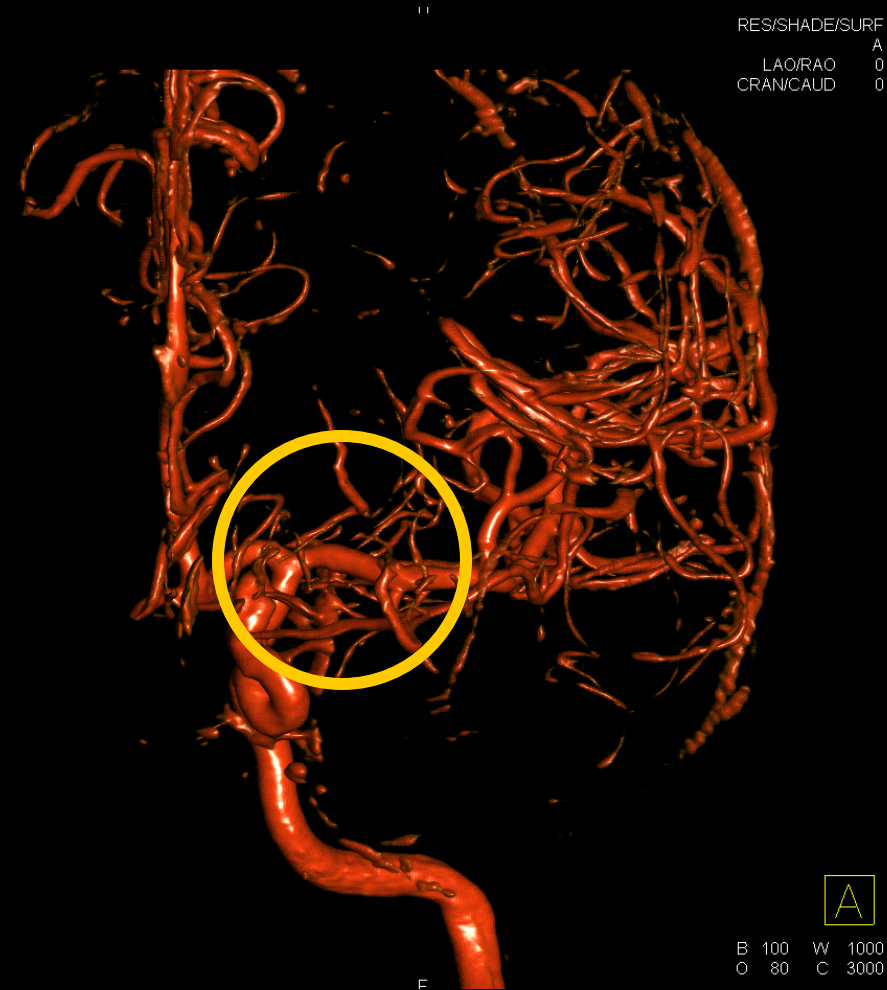
Large VOI: To include the entire scan field, e.g. AVM's or DynaCT's for registration purposes

# Slice Matrix

## 256 slice matrix

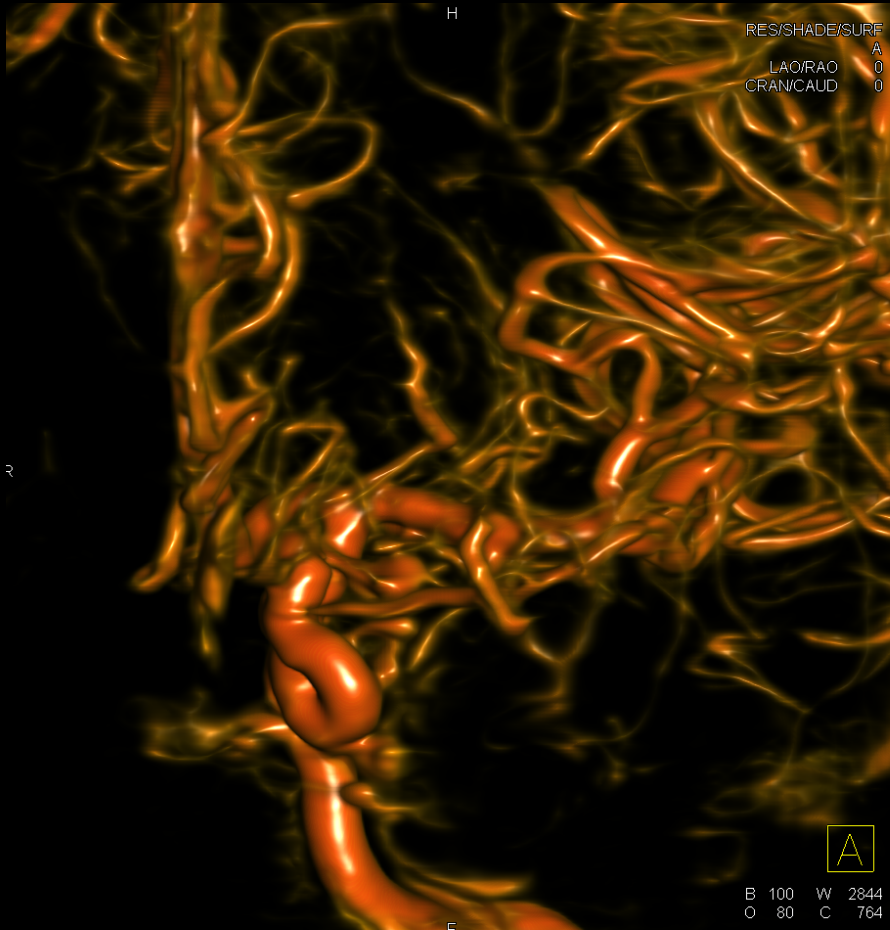


## 512 slice matrix

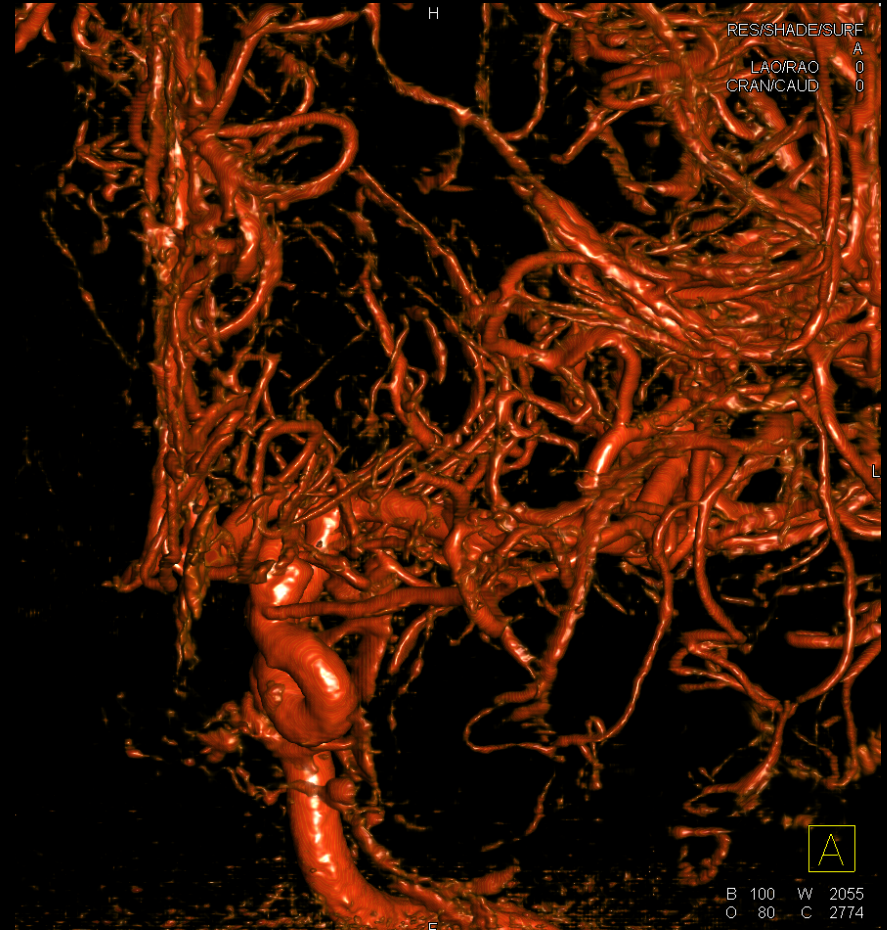


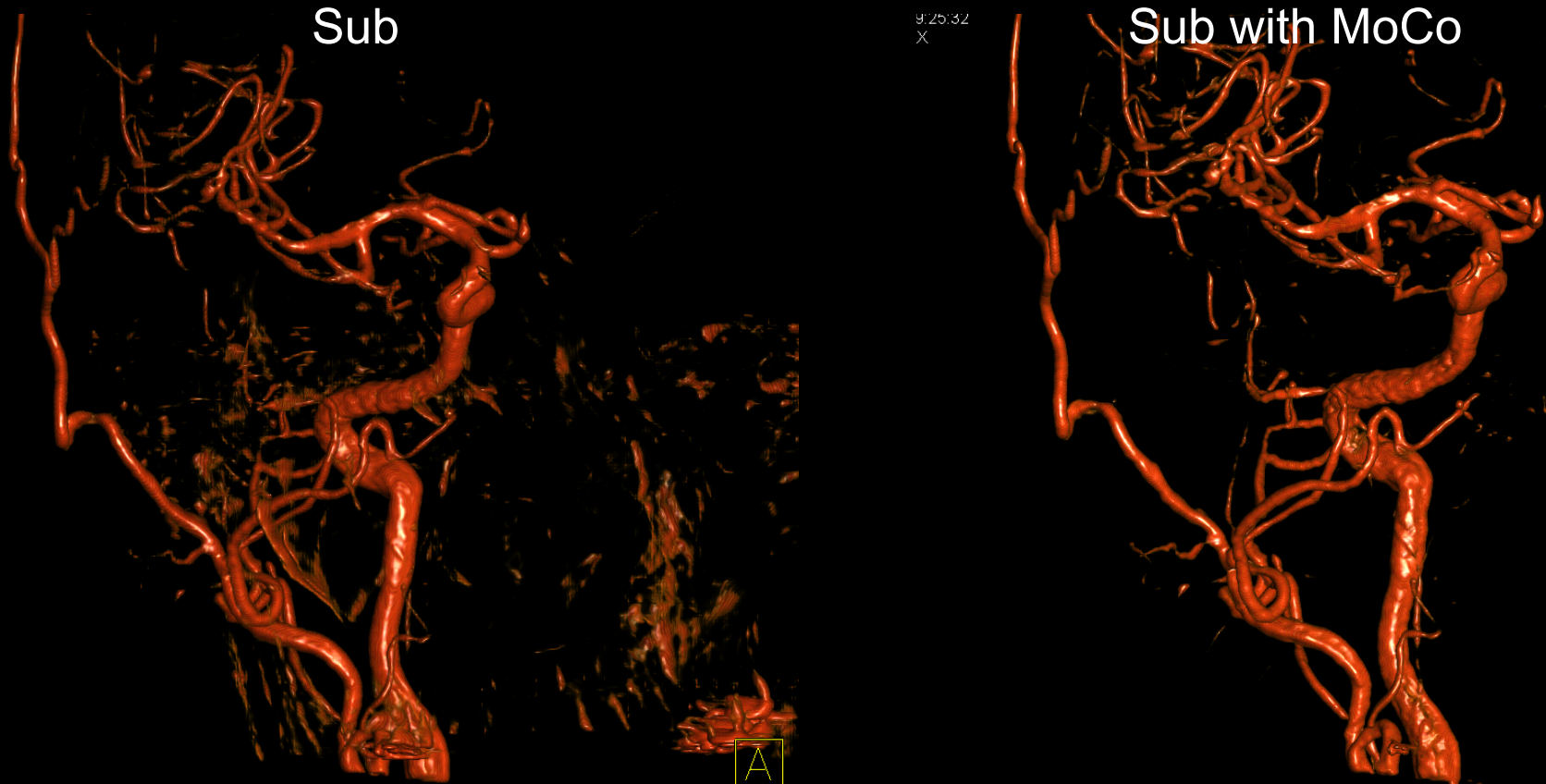
# Image Characteristics

## Smooth



## Sharp

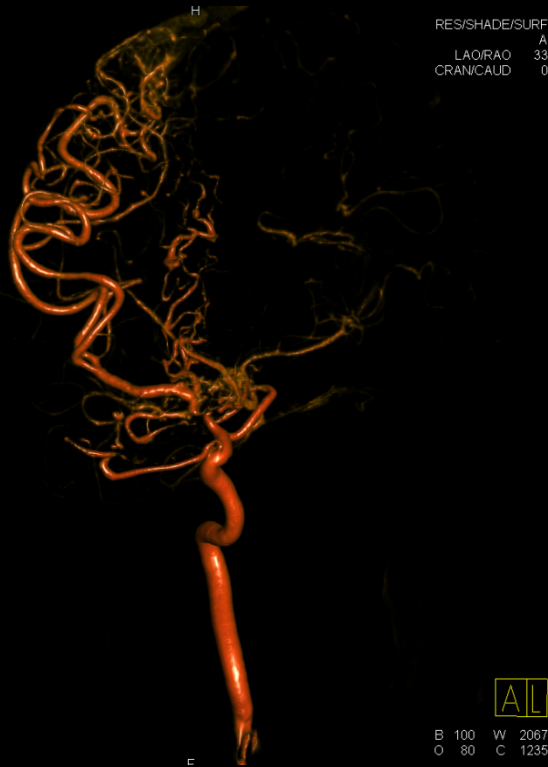




How to get there:

1. Load e.g. 5sDSA into InSpace Reconstruction (*Patient -> Send to 3D*)
2. Under *Reconstruction Mode* select “*Sub with MoCo*”
3. Start reconstruction

## Primary Reconstruction



## Secondary Reconstruction



### How to get there

1. Load e.g. 10sDSA into InSpace Reconstruction (*Patient -> Send to 3D*)
2. Under *Reconstruction Mode* select “*NatFill*”
3. Start reconstruction

Reconstruction Preset Editor

Preset	3D...	VOI Si...	Slice ...	Kern...	Image...	Auto...	Auto...	Recon...	Viewin...	Com...	LFD ...	Dyn...	Yes...	3D/3D...	Win...	Win...	Win...	Win...
Angio	1	Medium	512 x ...	EE	Normal	Yes	Yes	Sub	AutoV...	No	No	No	No	Rigid	1000	0	300	0
Aortic Valve Guide	28	Full	256 x ...	HU	Normal	Yes	Yes	Nat Fill	Aortic ...	No	No	No	No	Rigid	1000	0	300	0
Bone	2	Full	512 x ...	HU	Auto	Yes	Yes	Nat Fill	Opaq...	No	No	No	No	Rigid	1000	0	300	0
Cardiac Gated	5	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	Dyna...	No	No	No	No	Rigid	1000	0	300	0
Cardiac Ungated	6	Full	256 x ...	HU	Normal	Yes	Yes	Nat Fill	Dyna...	No	No	No	No	Rigid	1000	0	300	0
Dual Volume	3	Medium	512 x ...	EE	Normal	Yes	Yes	Dual V...	AutoD...	No	No	No	No	Rigid	1000	0	300	0
DynaCT Body	7	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	AutoD...	No	No	No	No	Rigid	330	60	1500	550
DynaCT Head	4	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	Dyna...	No	Yes	No	No	Rigid	330	60	1500	550
DynaCT Head Clear	31	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	Dyna...	No	Yes	Yes	No	Rigid	330	60	1500	550
iGuide_Bone	8	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	iGuide...	No	No	No	No	Rigid	2800	900	1000	0
iGuide_SoftTissue	9	Full	512 x ...	HU	Normal	Yes	Yes	Nat Fill	iGuide...	No	No	No	No	Rigid	350	80	1000	0
Liver-PBV	27	Full	512 x ...	HU	Smooth	Yes	Yes	Dual ...	Liver...	No	No	No	No	Flexible	100	200	550	1550
Neuro-PBV w/ vasc	25	Full	512 x ...	HU	Smooth	Yes	Yes	Dual ...	Neuro...	No	No	No	No	Rigid	62	29	550	1550
Neuro-PBV w/o vasc	26	Full	512 x ...	HU	Smooth	Yes	Yes	Dual ...	Neuro...	No	No	No	Yes	Rigid	62	29	550	1550
SAH/BLEED	10	Medium	512 x ...	EE	VeryS...	Yes	Yes	Sub	Dyna...	No	Yes	Yes	No	Rigid	1000	0	300	0
STEALTH_Skin	11	Full	512 x ...	HU	Smooth	Yes	Yes	Nat Fill	Dyna...	No	No	Yes	No	Rigid	2500	570	300	0
STEALTH_Sub	12	Full	512 x ...	EE	Normal	Yes	Yes	Sub	AutoG...	No	No	No	No	Rigid	1000	0	300	0
Stent Follow-Up	29	Small	512 x ...	EE	Sharp	Yes	Yes	Nat Fill	DCT_...	No	Yes	Yes	No	Rigid	1000	0	300	0

Overall Default Preset: Stent Follow-Up      DynaCT Recon: Stent Follow-Up

New Entry    Delete Entry    Edit Entry    Cancel    Save    Help

- Each preset is linked to a protocol on the Artis
- Stores all reconstruction parameters specific to each protocol
- Create custom secondary reconstructions (e.g. SAH/BLEED using a VerySmooth image characteristic)

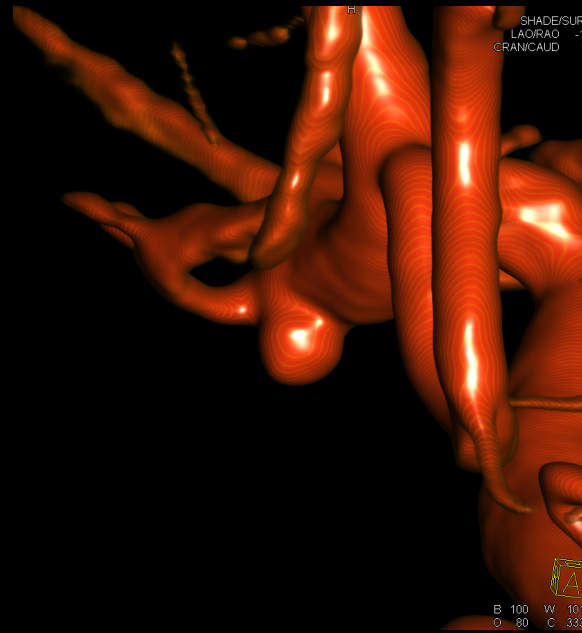


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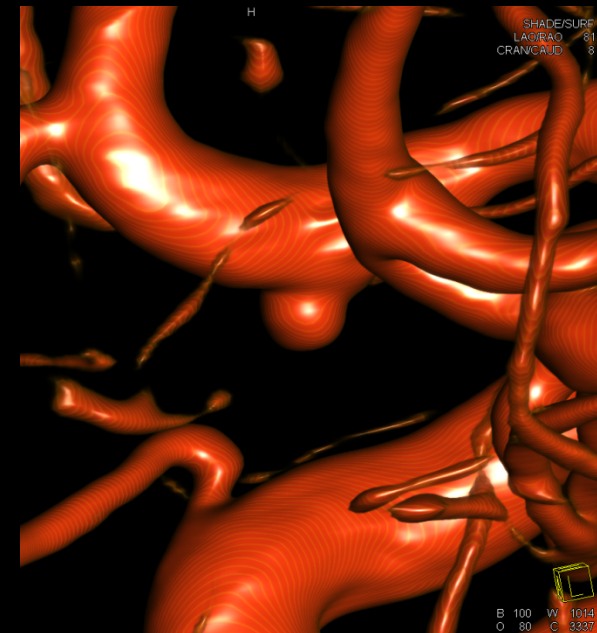
Default AP view



Anterior oblique view

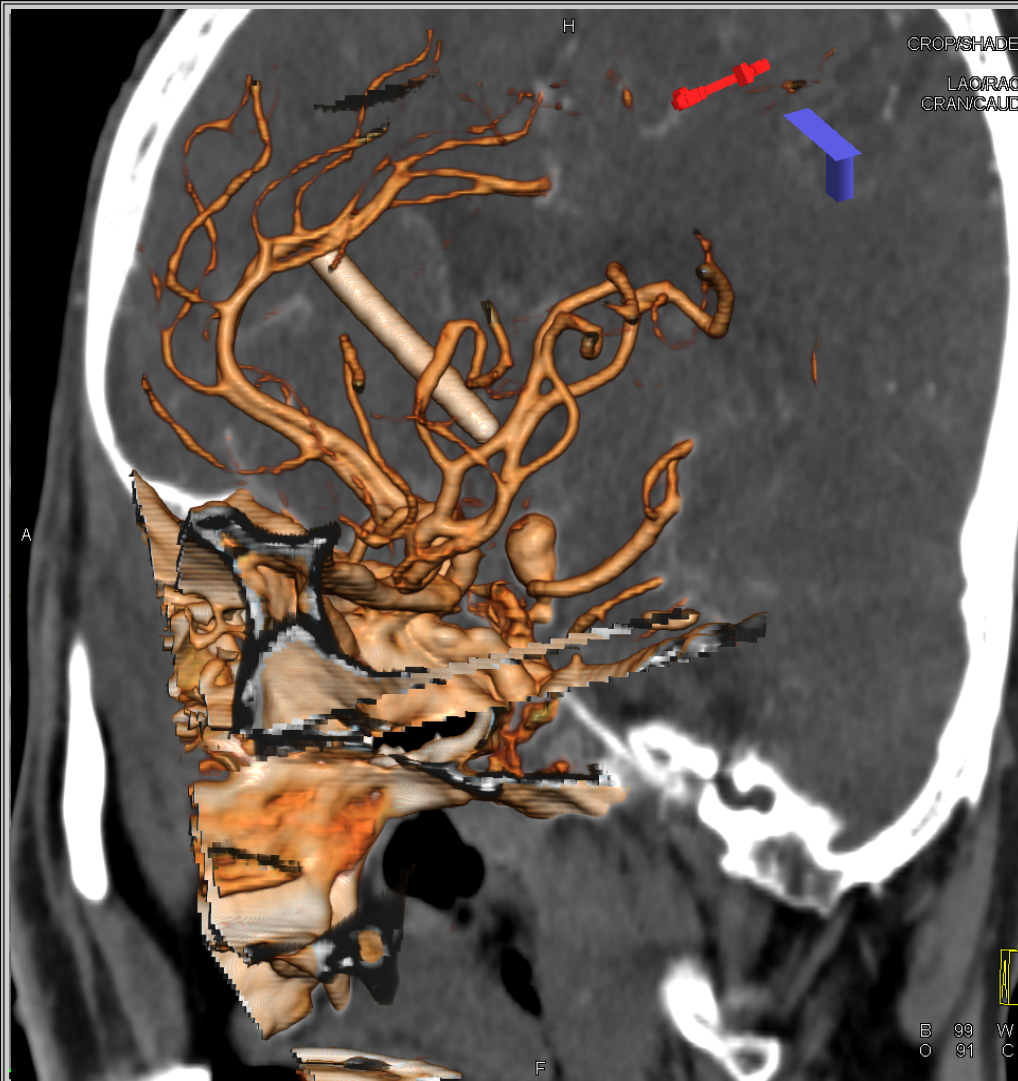


Left oblique view



# Embedded MPR in ruptured aneurysms

Patient Applications InSpace Show Mode View Orientation Tools Measure Volumes Options Help



The main window displays a 3D reconstruction of a ruptured aneurysm. The aneurysm is shown in orange, with its parent artery in white. A red cylindrical structure is visible at the top, and a blue rectangular structure is visible on the right. The background is a grayscale CT scan of the skull. The interface includes a menu bar at the top with options: Patient, Applications, InSpace, Show, Mode, View, Orientation, Tools, Measure, Volumes, Options, Help. On the right side, there are three vertical tabs: Filming, 3D, and InSpace. Below these are two more tabs: Angio and another unlabeled one. The Angio tab is active, showing a 'Clip' menu with options: Oblique (checked), Posterior, Feet, Head, Right, Left. The 'Oblique' option is highlighted with a green box. The '3D' tab shows a 'Type' menu with various icons. The 'InSpace' tab shows 'Brightness' and 'Opacity' sliders. The 'Filming' tab shows various camera control icons. The 'Angio' tab also shows a 'Tools' menu with icons for various functions. The bottom right corner of the main window displays technical data: B 99 W, O 91 C.

CROP/SHADE/  
LAC/RAO  
CRAN/CAUD

A H

B 99 W  
O 91 C

F

Filming

3D

InSpace

Angio

Type Orient Table 2D

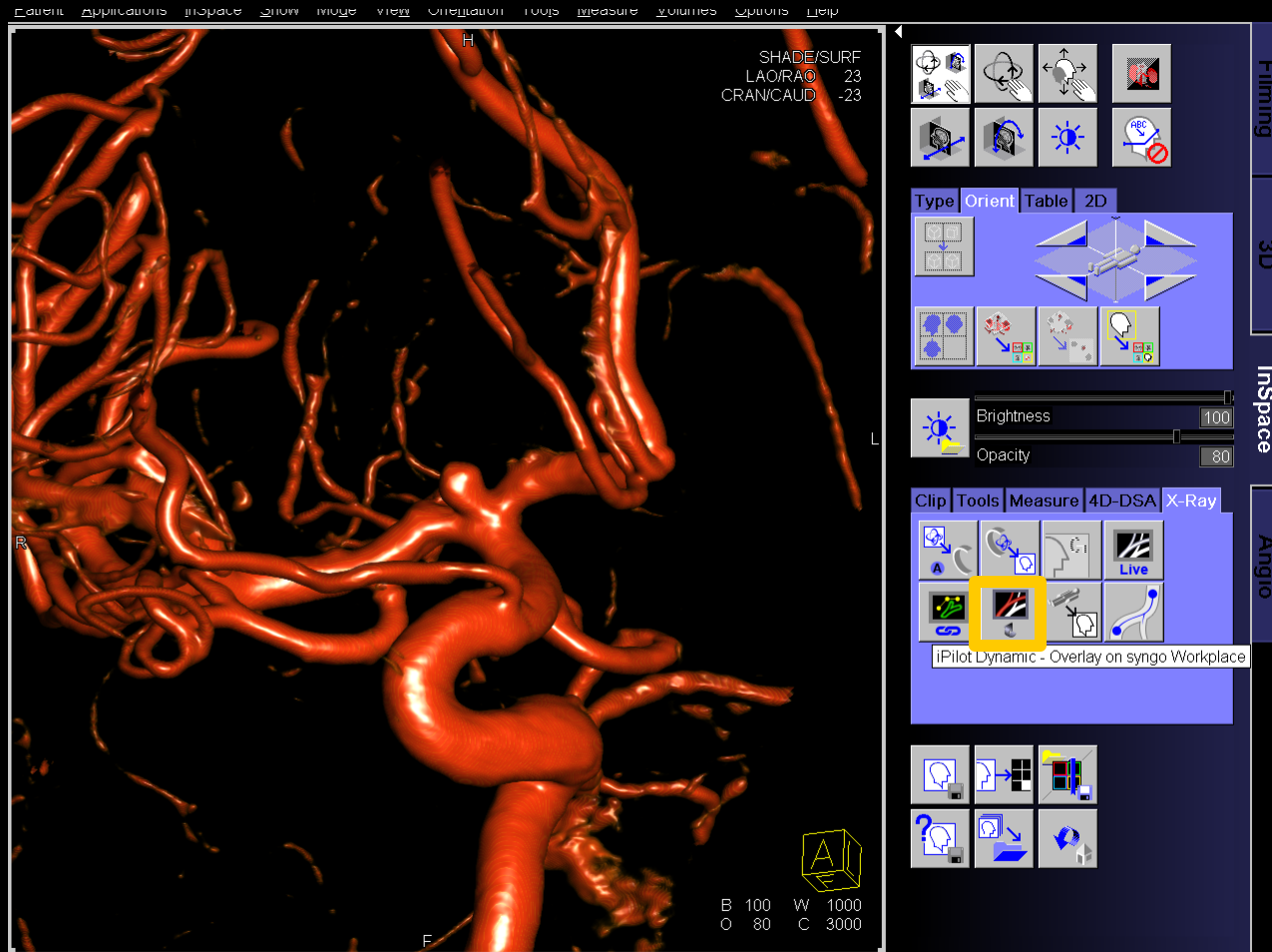
Brightness 100  
Opacity 80

Clip Tools Measure 4D-DSA X-Ray

Oblique  Posterior  
 Feet  Head  
 Right  Left

# 3D Roadmap

- Optimal treatment projection of ICA bifurcation aneurysm
- Click on *iPilot Dynamic* to overlay this view to live fluoro on the workstation monitor



# 3D Roadmap

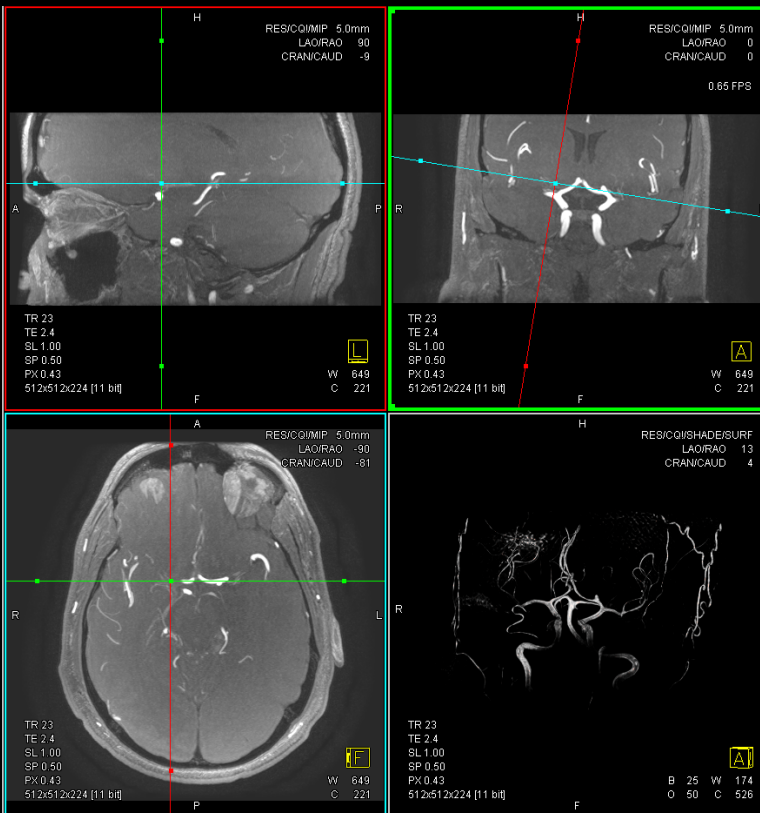
Guidewire

Stent microcatheter

Coiled aneurysm

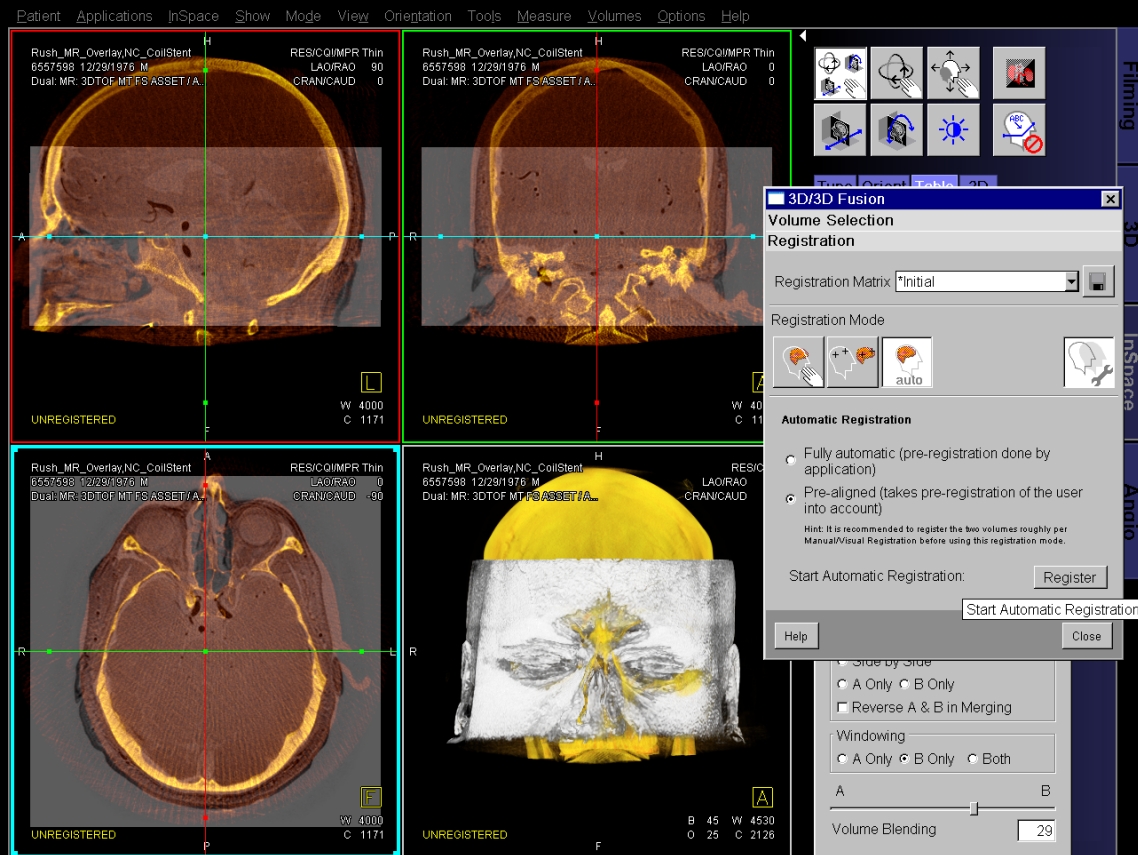


- MRA (3D TOF\*) to visualize the aneurysm
- 5sDR non-contrast for registration
- Load both to InSpace, click on *Fusion*

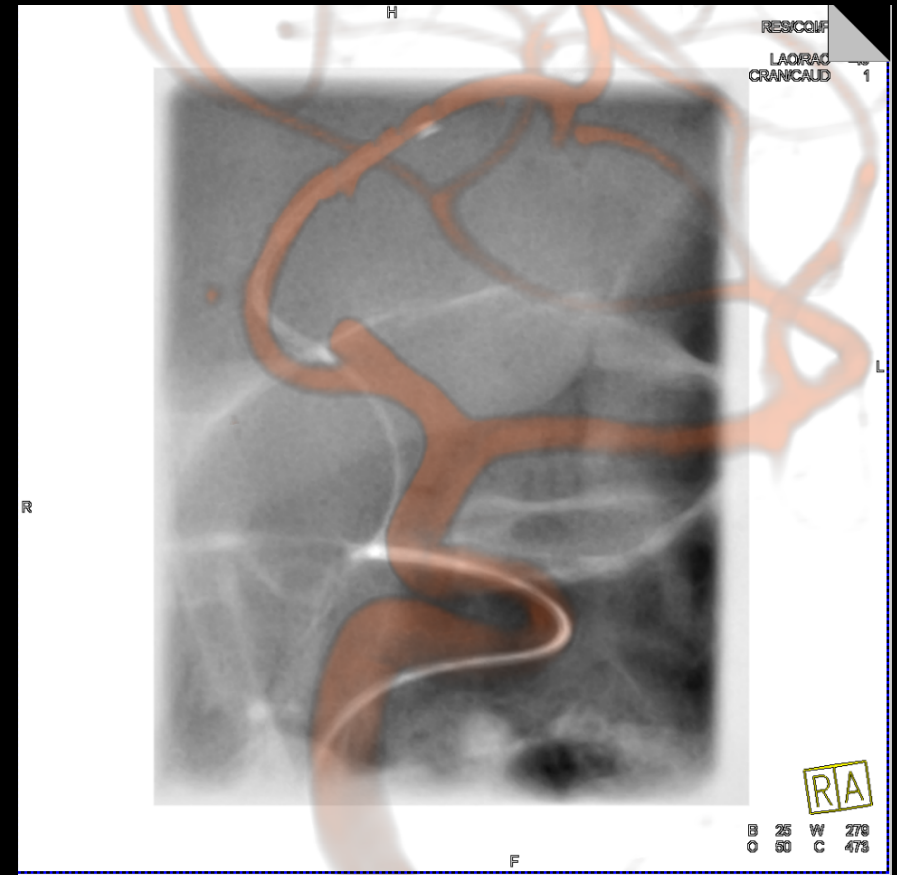
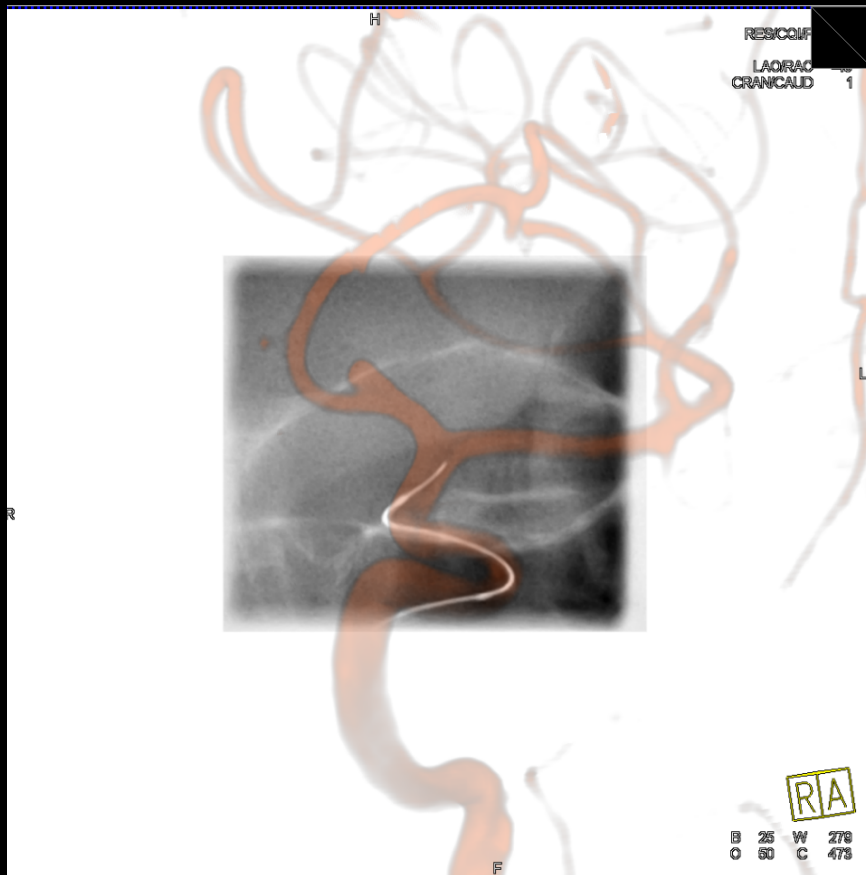


\* TOF: Time of Flight

- Align both datasets, click on *auto*, *Pre-aligned*, *Register*
- Check registration, then save Registration Matrix
- Close patient data and load only the MR dataset in InSpace
- Click on iPilot Dynamic to overlay



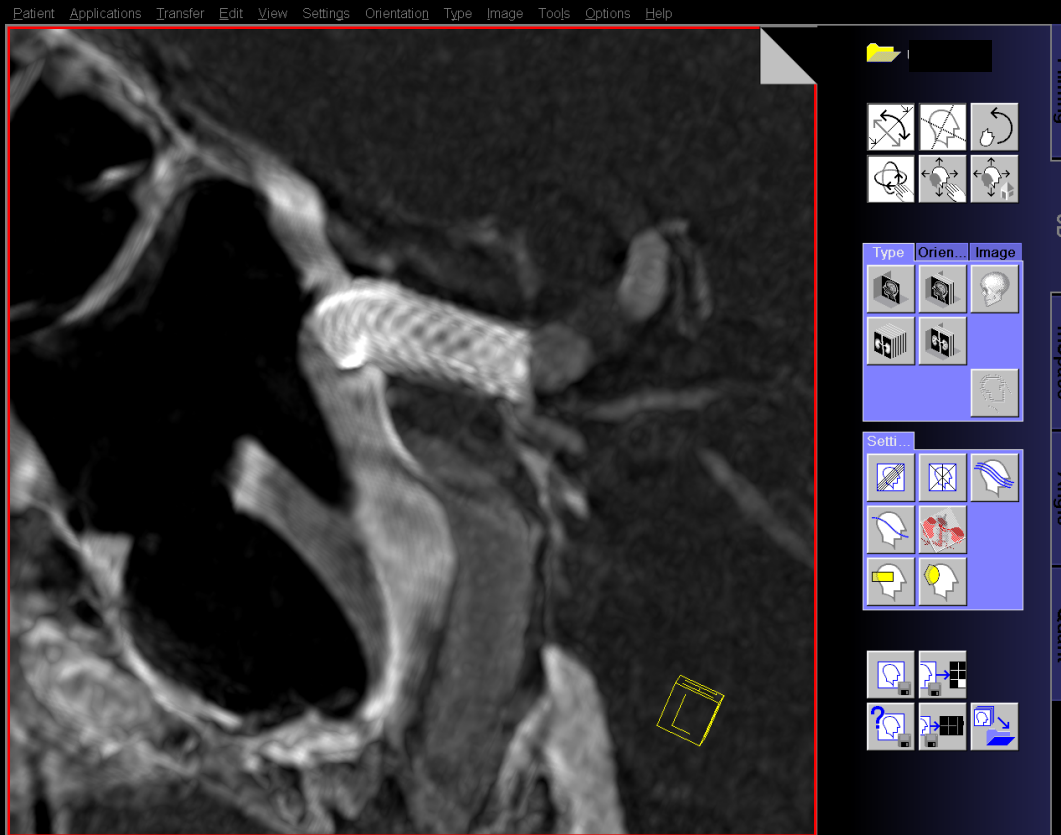
- MRA (3D TOF) to visualize the aneurysm
- 5sDR non-contrast for registration



Optional: In the *iPilot Dynamic* window select *Invert Gray Scale* and change the MR preset

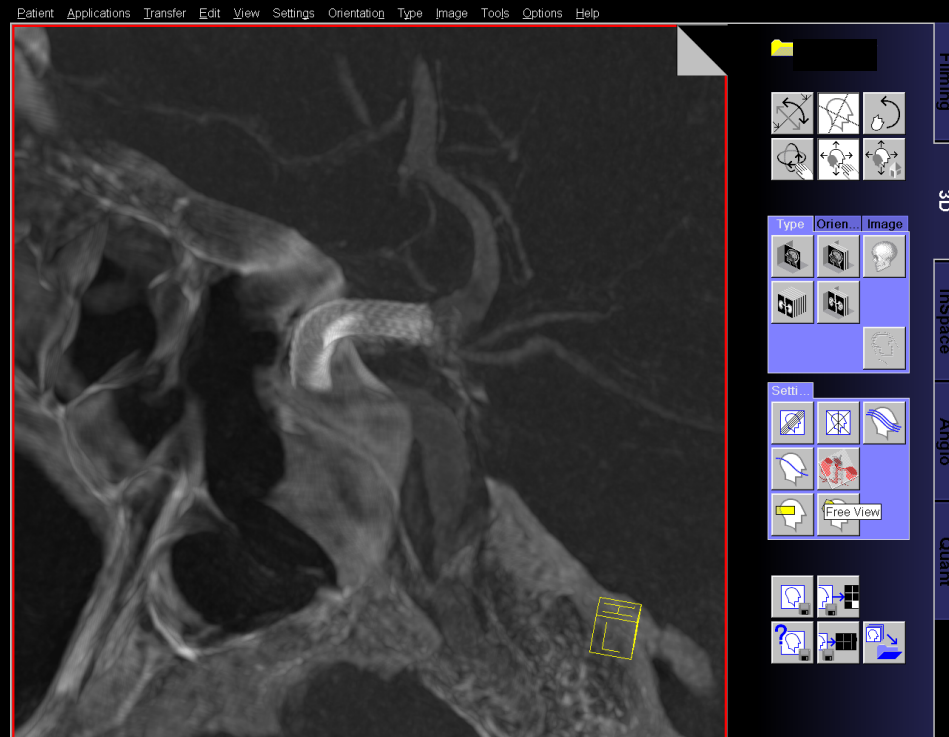
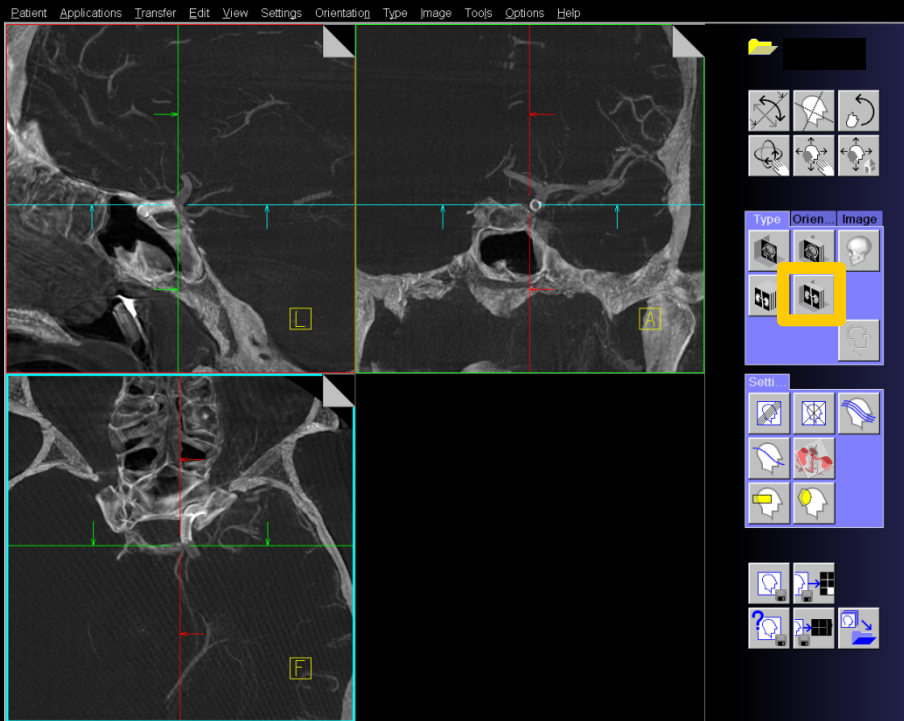


- Perform 2<sup>nd</sup> reconstruction with small VOI, centered on the area of interest (e.g. stent, flow diverter)
- Create individual images to best visualize the device and its relation to bone or other vessels

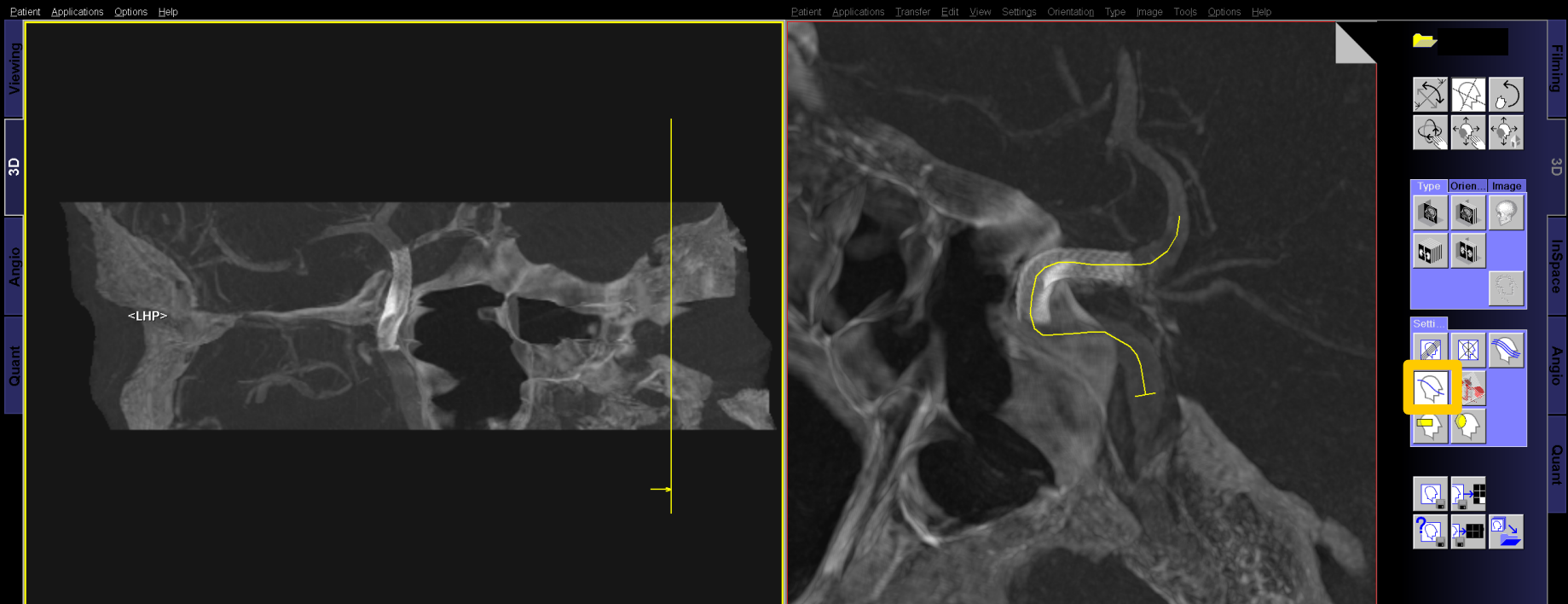


Load dataset to 3D card and change to thin MIP and adjust window settings

Rotate until area of interest is in profile

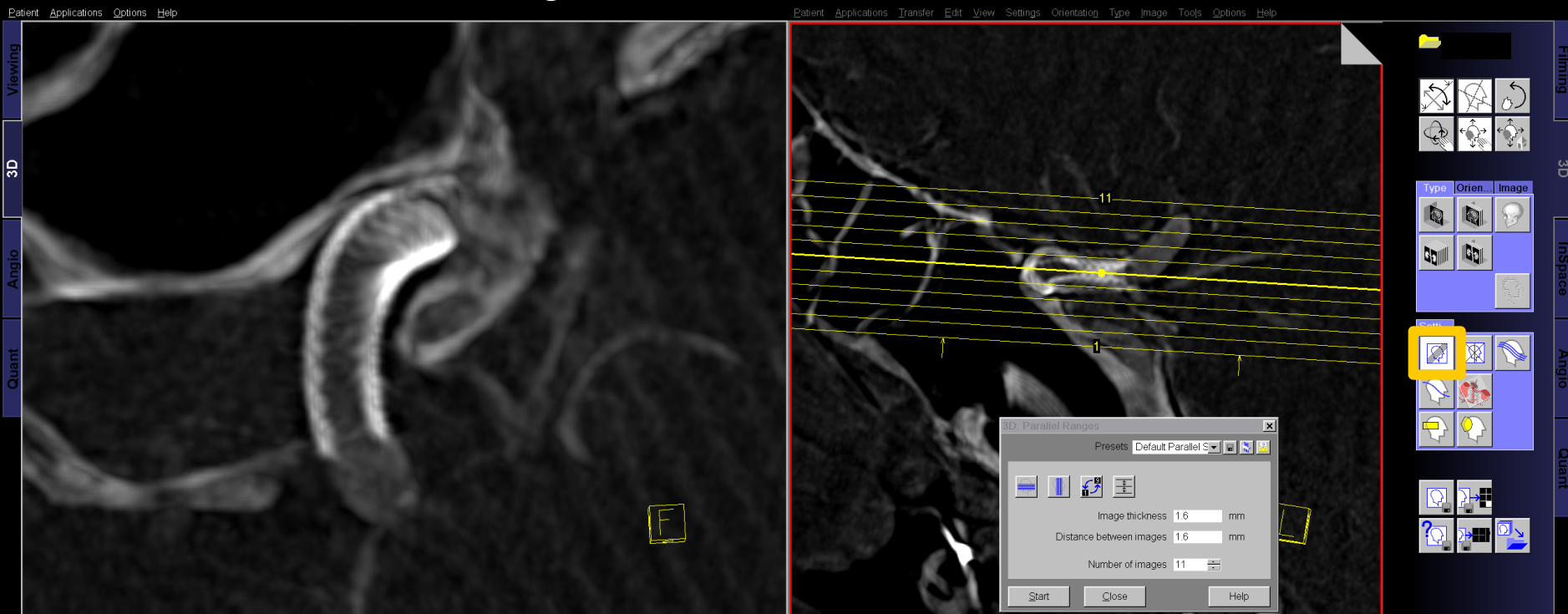


Select the *Curved Mode* icon and draw a line, following the course of the vessel, end with a double click, the result will be shown on the 2<sup>nd</sup> monitor

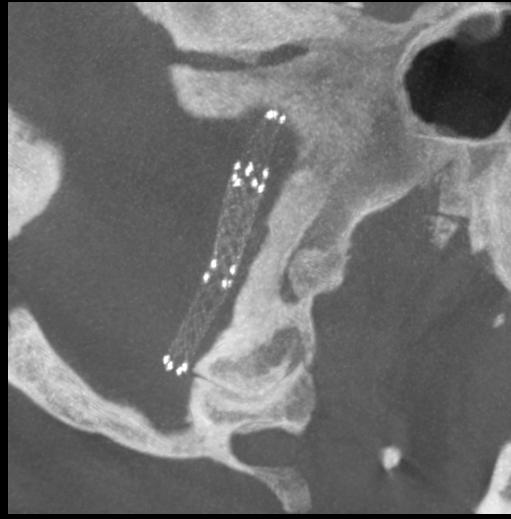
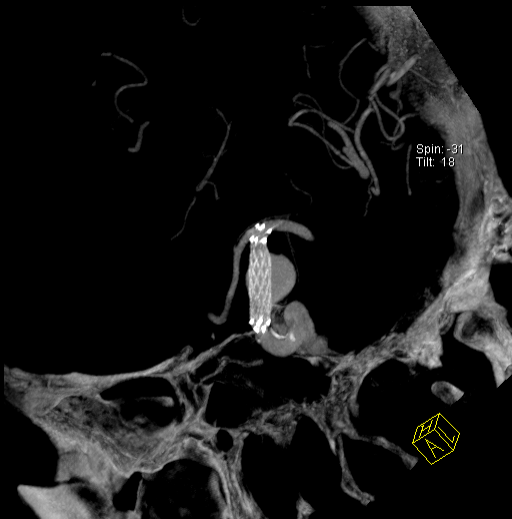
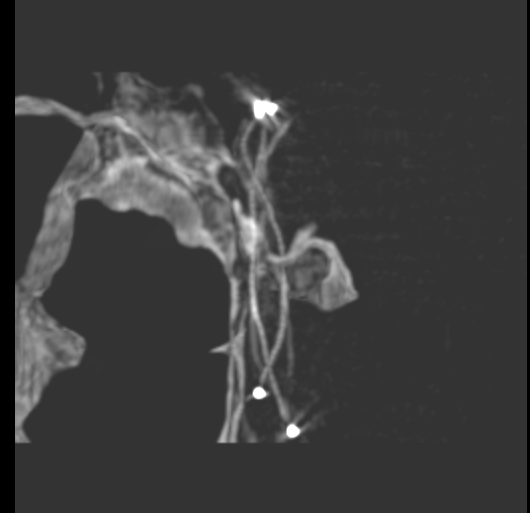
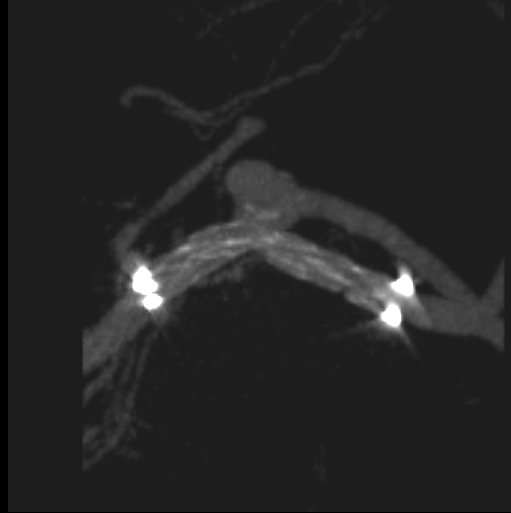
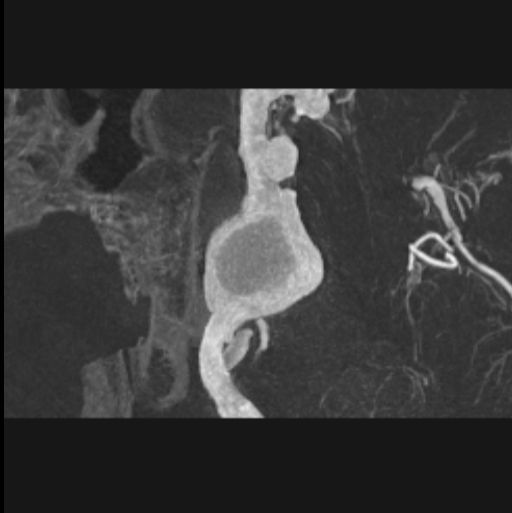


# Parallel MRP/ MIP ranges

- Select *Parallel Ranges* icon, position the centerline on the stent and tilt the ranges to follow the vessel
- Adjust parameter so that *Image thickness = Distance between slices*
- Deselect *Keep number of images constant* and adjust the range to cover the area of interest
- Start and save the range after reconstruction



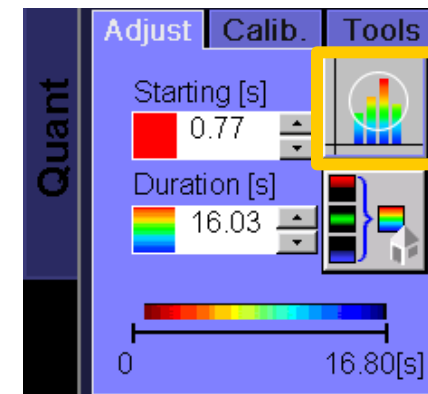
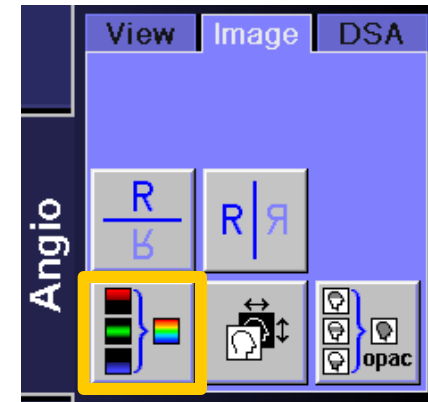
# Results of 3D post processing



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# syngo iFlow – Intro & Workflow

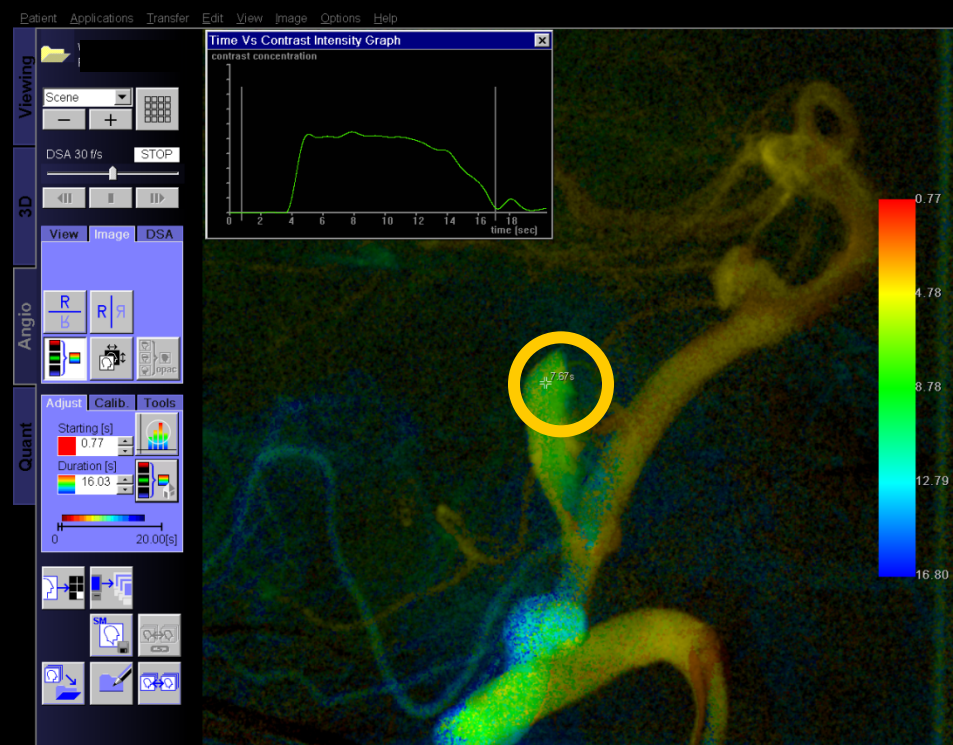
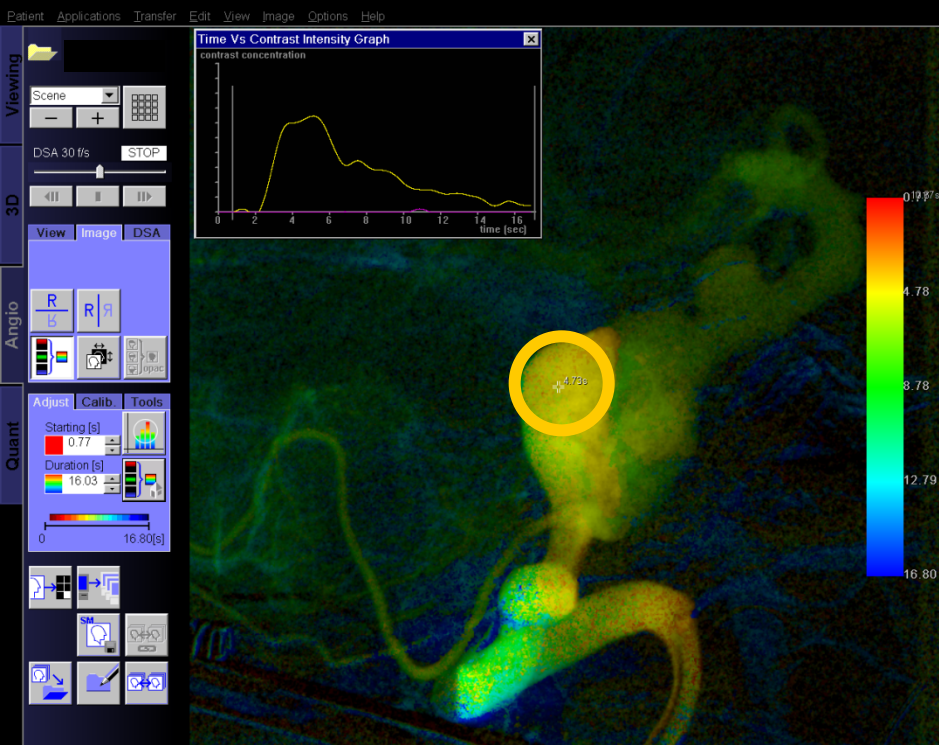
- Provides a single composite image that shows the history of the contrast medium movement through the vessel in time in a colored image
- Required images: 2D DSA acquisitions with positive contrast (iodine)
- Load 2D DSA images in *Angio* taskcard
- Select *iFlow* icon on *Image* tab card
- To compare 2 runs, e.g. pre and post flow diverter placement, make sure that *Starting* time and *Duration* is the same for both runs
- Place the cursor over the image to see the time of maximum contrast, click to set a marker
- To make ROI measurements click on *Total Contrast ROI selection* icon and place a circular, rectangular or freehand ROI



## Giant aneurysm in left ICA

Pre flow diverter placement

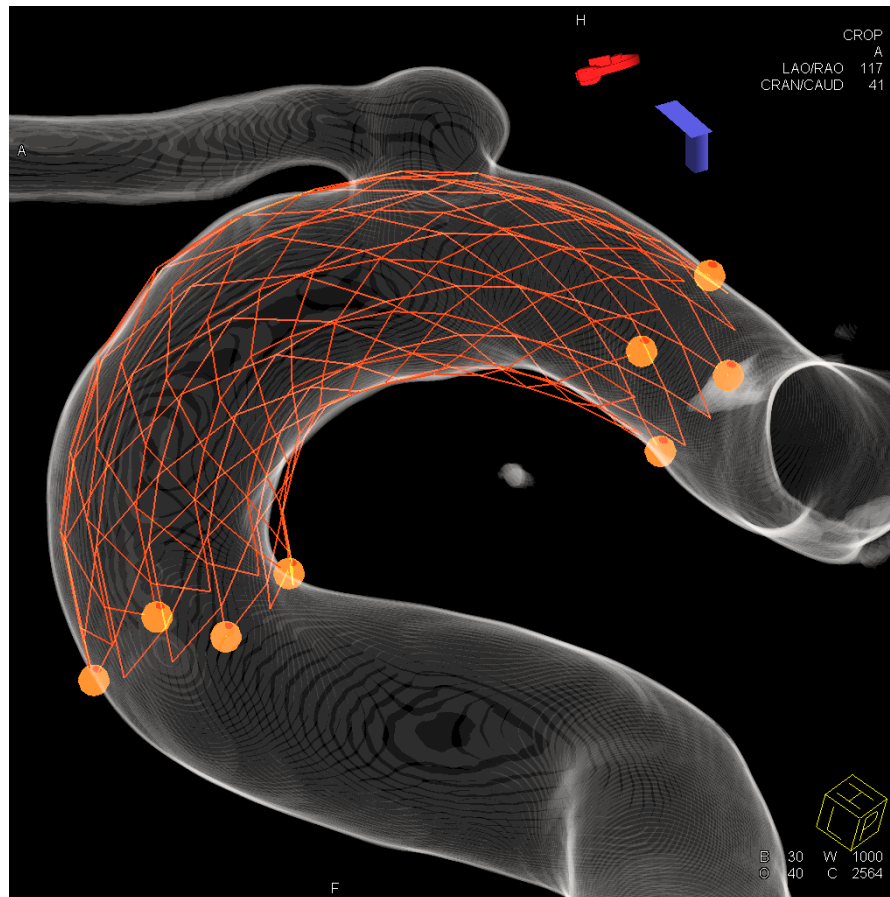
Post flow diverter placement



Contrast enhancement in aneurysm is clearly delayed after FD placement

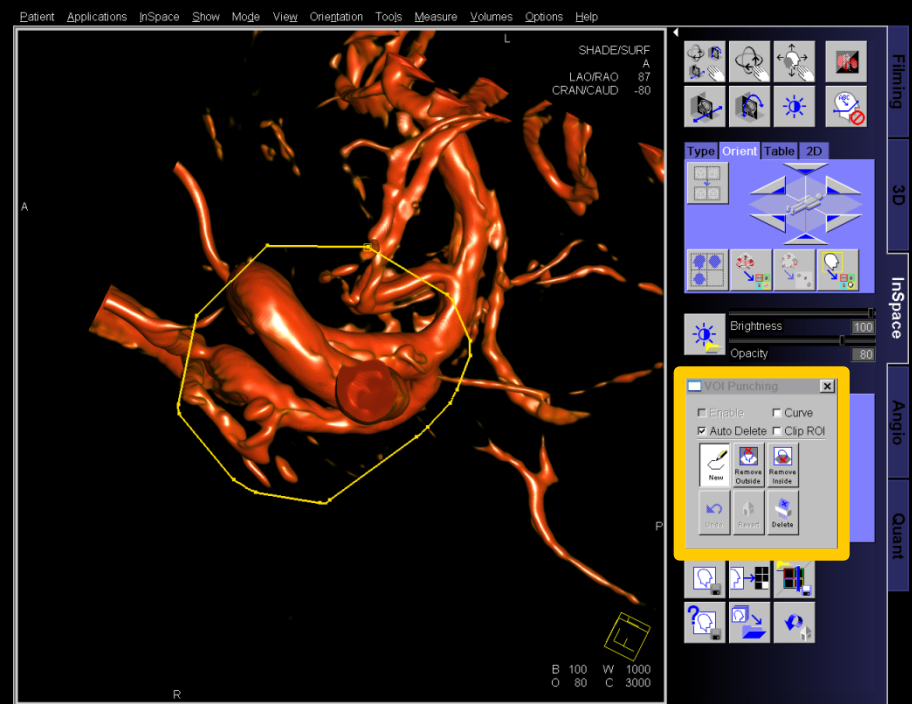
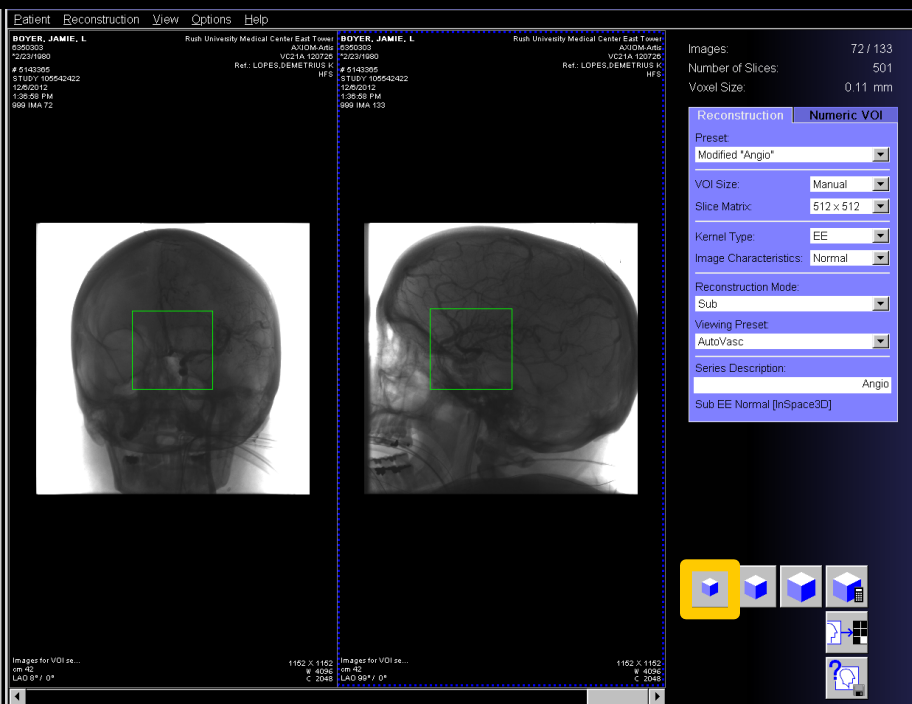


- Allows precise stent planning in complex cases
- Results can be overlaid to live fluoro for guidance during stent deployment



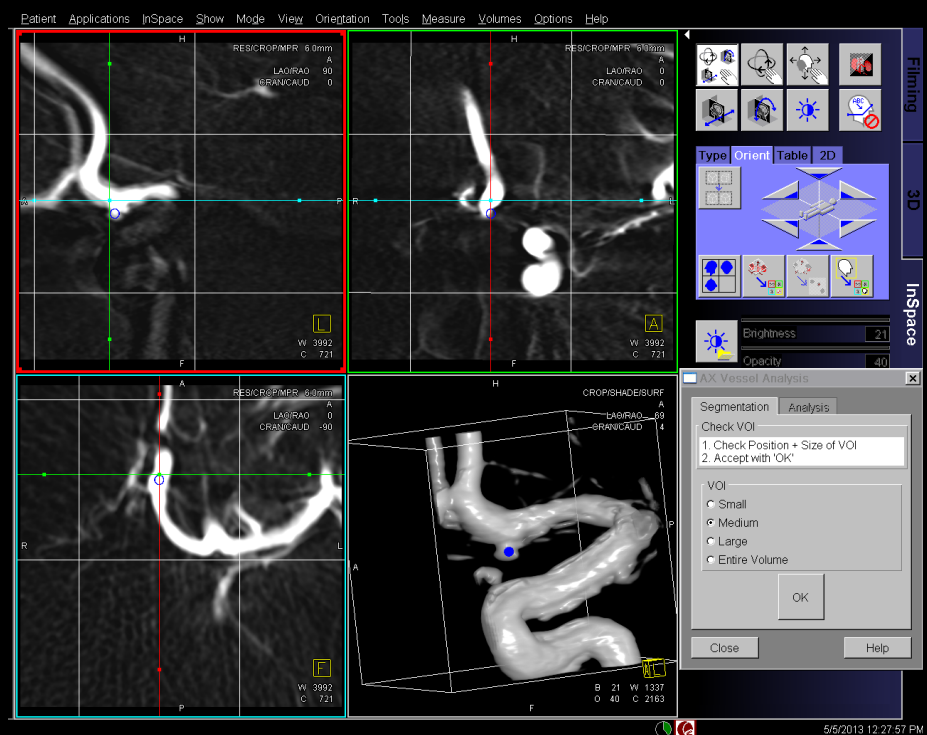
Perform 2<sup>nd</sup> recon with small VOI for best image quality for best image quality

VOI Punching to delete all vessel around the area of interest



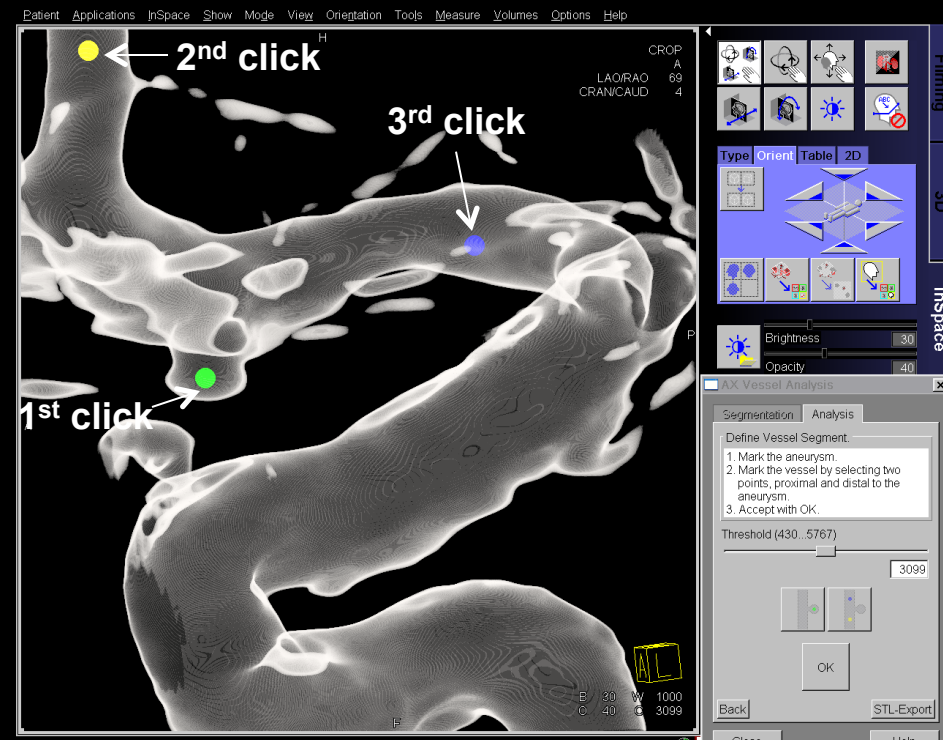
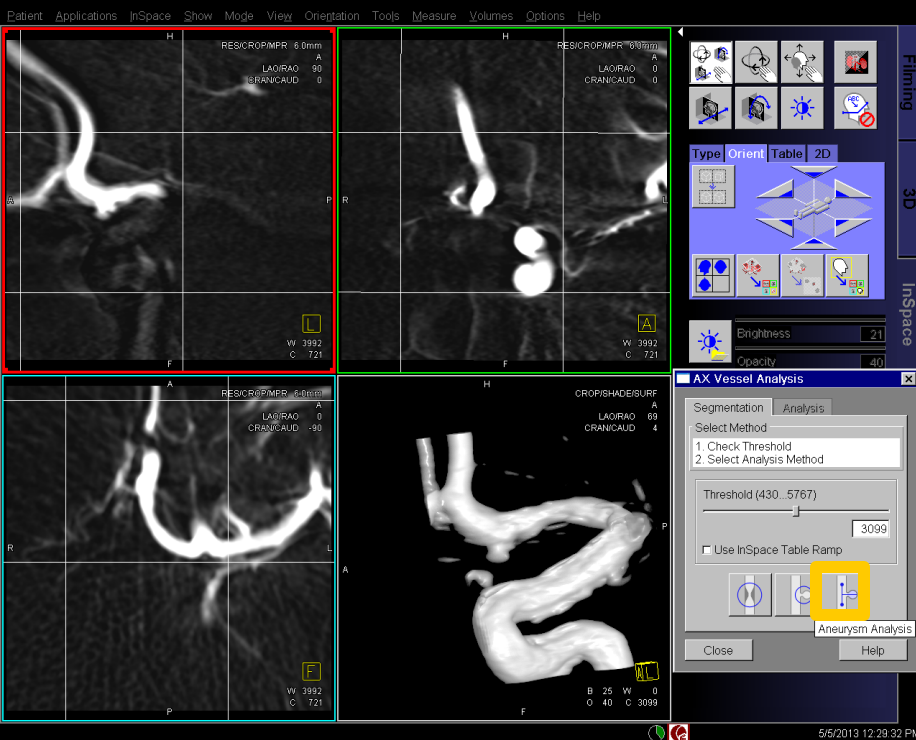
Select *AX Vessel Analysis* icon  
on *Measure* tab card

Make sure that *VOI* is centered on  
aneurysm (blue dot) and click *OK*



Click on *Aneurysm Analysis*

Click inside the aneurysm, than proximal and distal, click OK



Check centerline + aneurysm measurement, click on *Virtual Stent*

Change stent length and position, click on iPilot to overlay to fluoro

This screenshot shows the software interface for Step 7. The top-left panel displays a 2D axial CT scan with a red dashed line indicating a measurement of 6.4 mm. The top-right panel shows a 3D reconstruction of the vessel with a red centerline. The bottom-left panel is a graph of vessel diameter (D mm) versus length (L mm), with a red vertical line at 9.5 mm. The bottom-right panel shows a 3D vessel model with a red rectangular box highlighting the aneurysm. The 'AX Vessel Analysis' panel is open, showing the 'Segmentation' tab with instructions: '1. Inspect aneurysm & segment vessel measurements. 2. Select Virtual Stent to overlay stent.' The 'Virtual Stent' button is highlighted with a yellow box.

Segment L:	200 mm	Aneurysm Properties
Mean Prox. D:	3.6 mm	Volume
Mean Dist. D:	2.7 mm	Surface A:
MPI Properties		Dome Height:
Ostium Angle	n/a	Max. Dome Width:
Max. D:	4.4 mm	Ostium (Neck) L:
Mean D:	3.9 mm	Ostium Max. D:
Stent D:	n/a	Ostium Min. D:
Stent Properties		Ostium A:
Stent L:	n/a	Surface/Ostium A:
Stent C:	n/a	Volume/Ostium A:

This screenshot shows the software interface for Step 8. The top-left panel shows the 2D axial CT scan with a yellow circle highlighting the aneurysm. The top-right panel shows the 3D reconstruction with a yellow wireframe stent overlaid on the vessel. The bottom-left panel shows the diameter graph with a yellow box around the 9.5 mm mark. The bottom-right panel shows the 3D vessel model with the yellow wireframe stent. The 'AX Vessel Analysis' panel is open, showing the 'Analysis' tab with instructions: '1. Verify or adjust stent dimensions and position. 2. Select iPilot for overlay.' The 'iPilot' button is highlighted with a yellow box.

Segment L:	200 mm	Aneurysm Properties
Mean Prox. D:	3.6 mm	Volume
Mean Dist. D:	2.7 mm	Surface A:
MPI Properties		Dome Height:
Ostium Angle	n/a	Max. Dome Width:
Max. D:	4.4 mm	Ostium (Neck) L:
Mean D:	3.9 mm	Ostium Max. D:
Stent D:	3.6 mm	Ostium Min. D:
Stent Properties		Ostium A:
Stent L:	110 mm	Surface/Ostium A:
Stent C:	4.0 mm	Volume/Ostium A: