Roles of CT in Successful TAVI

New Technology & Co-Registration

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Major Uses of CT in TAVI

- Ileofemoral Arterial Sytem :
  Size, Calcification, Tortuosity, Plaques
- 3D annular & root morphology & dimensions
- Amounts of calcium in valve
- Optimal angle (TF) or puncture site (TA)
- Relationship of annulus to both coronary ostia
- Post TAVI assessment

Aortic Valve Morphology & Amount of Calcium

Scanty calcium

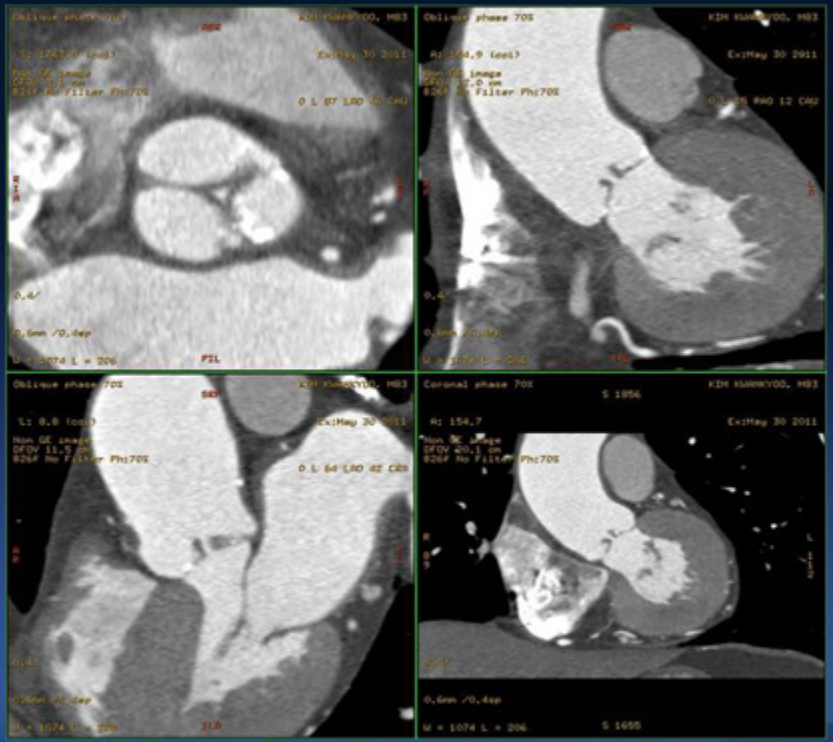
Heavy eccentric calcium

Echocardiographic findings

It is hard to deterimine how much calcium is in valve

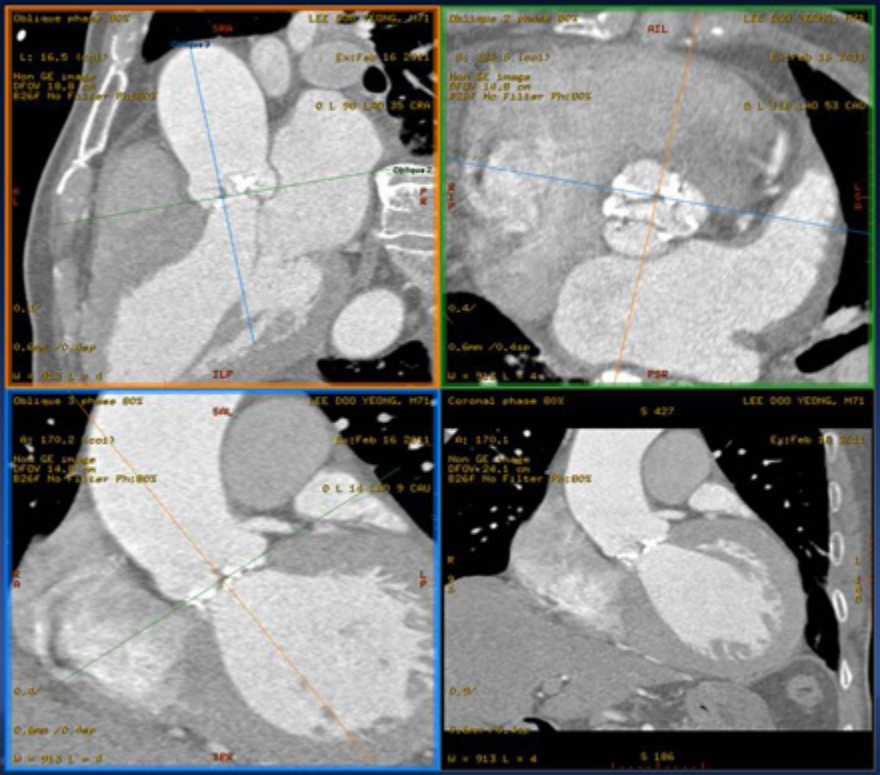
TEE TTE

Lack of Calcium

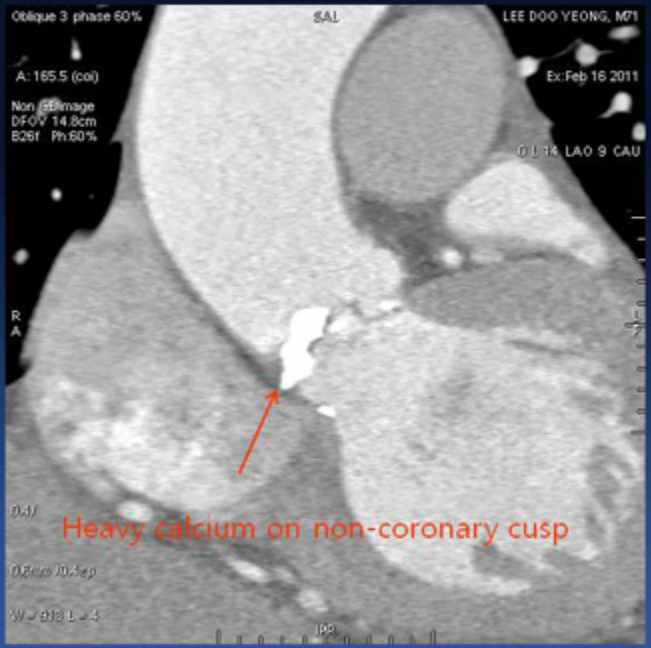


It is risk factor for migration or annulus rupture

Heavy Eccentric Calcium



Heavy Eccentric Calcium



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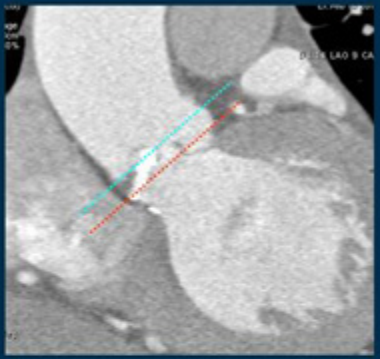
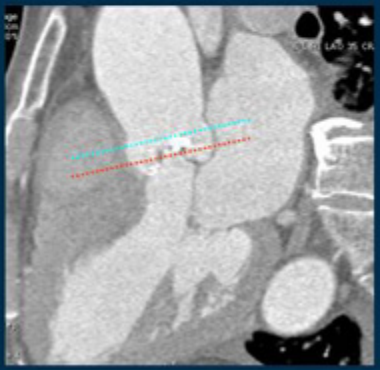
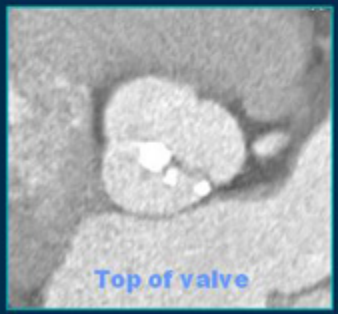
Heavy Eccentric Calcium







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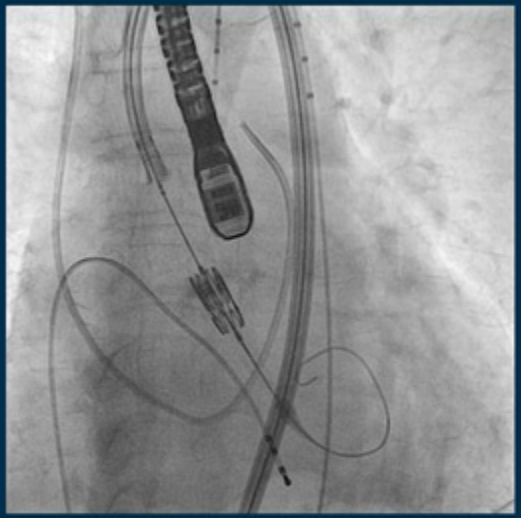
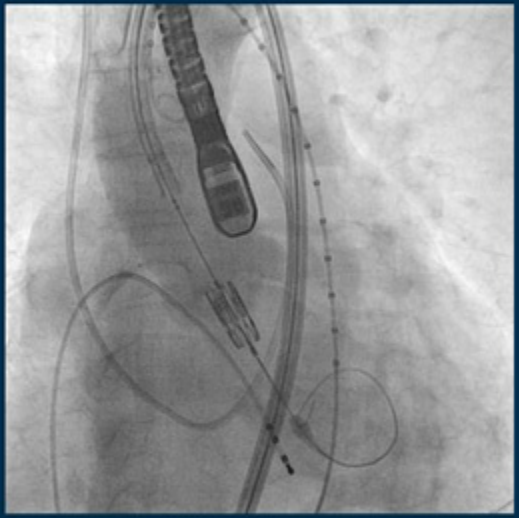
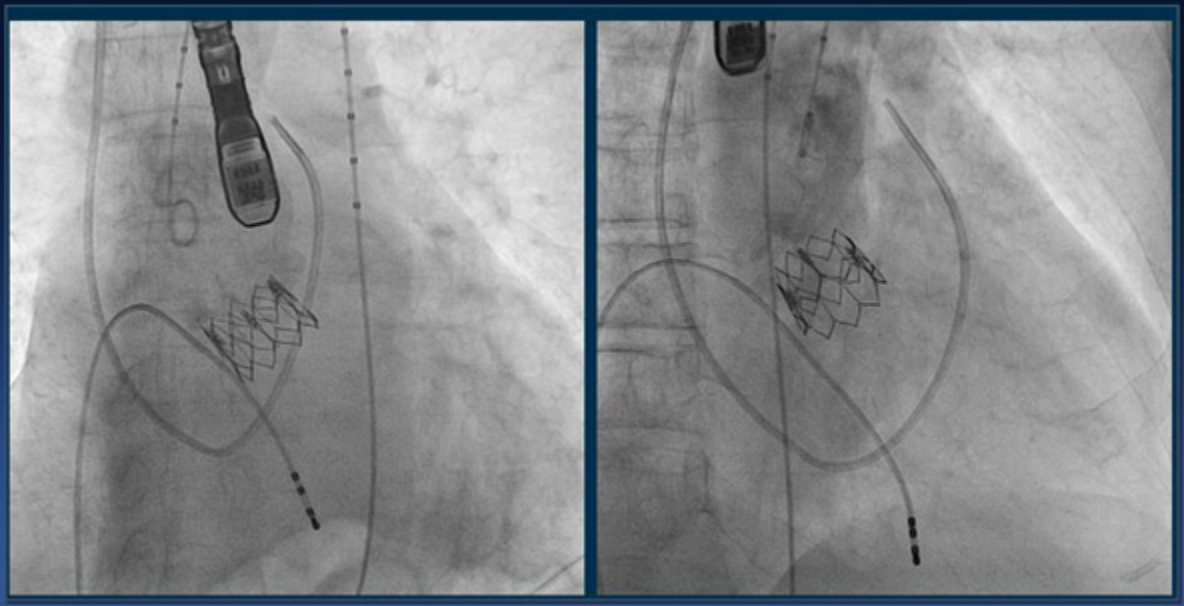
Valve Position & Implantation





LAO 1 CAUD 26 ; 26mm Valve

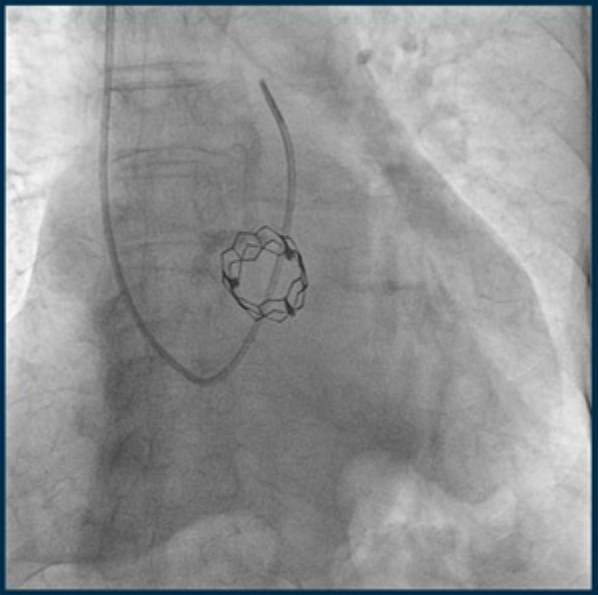
Final Aortogram

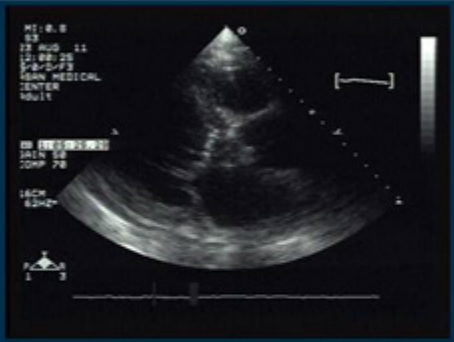


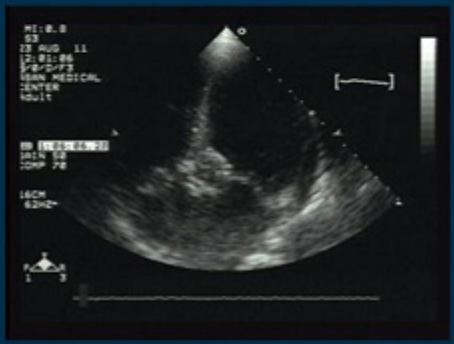
Echocardiographic evaluation

Mild to moderate PVL,
No severe AR sign in pressure curve

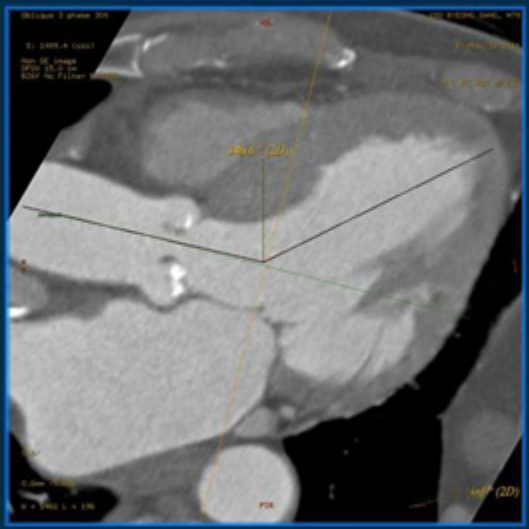
Sudden Drop of Vital Sign, Embolized valve to LVOT

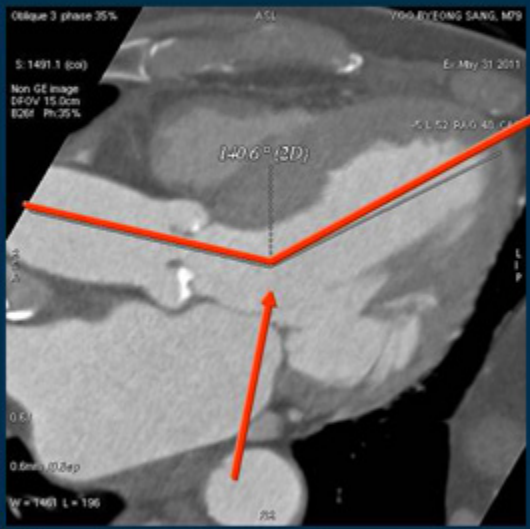






Navigator For Transapical Approach





Direction of Puncture or Wire

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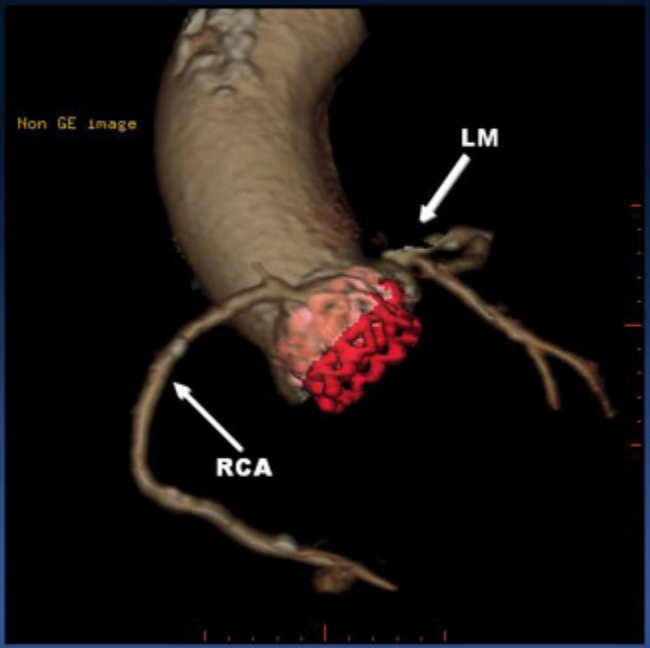
Follow up evaluation

Volume Rendering Image



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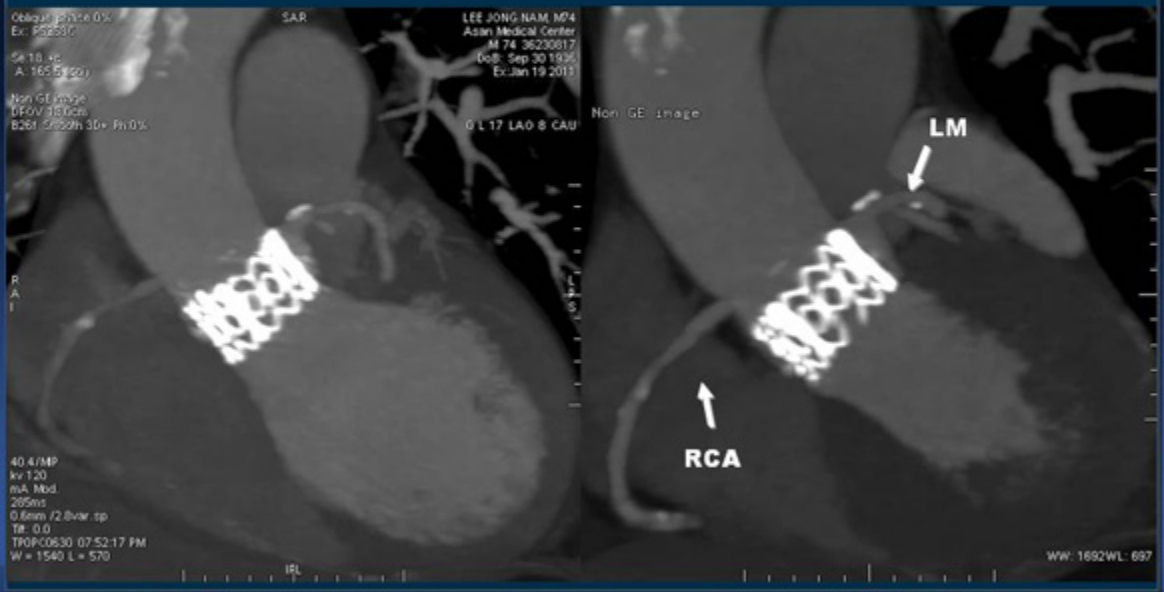
Spatial relationship with surrounding structures

Coronal View



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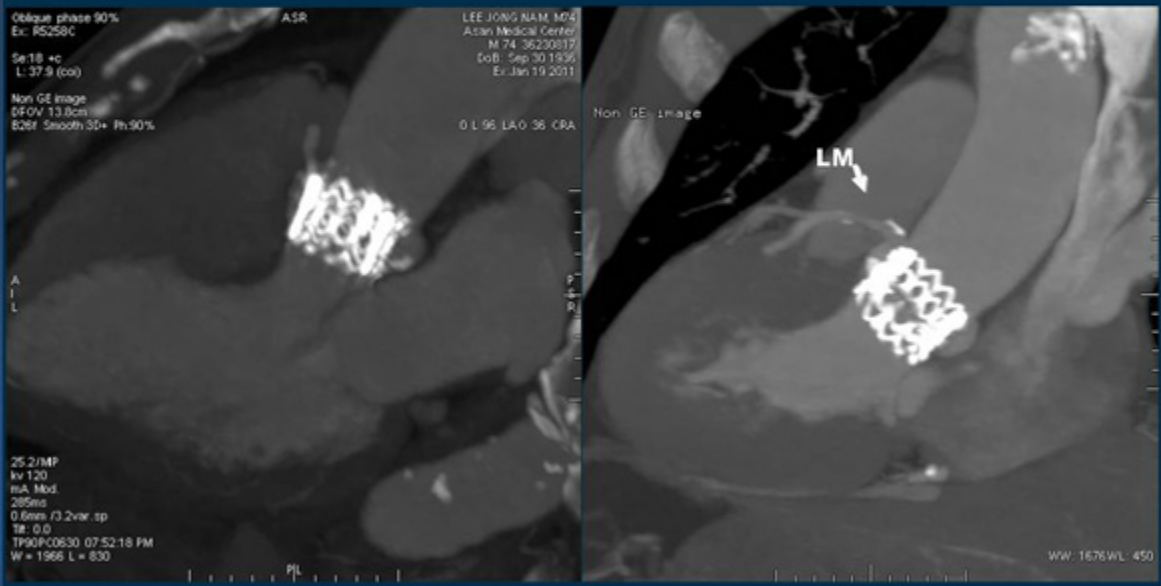
Spatial relationship with surrounding structures

Sagittal View



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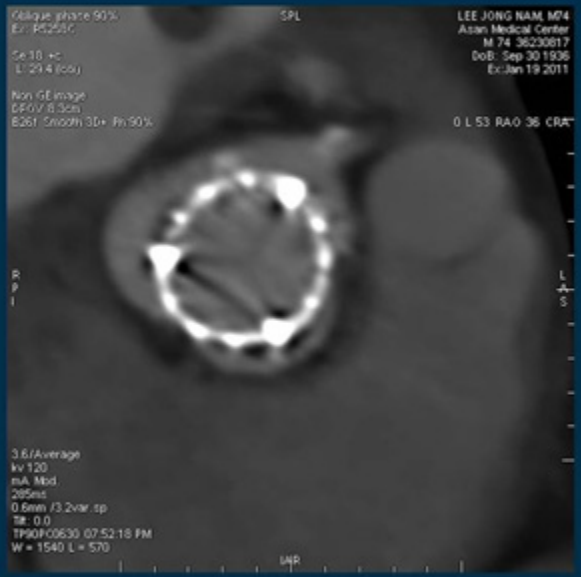
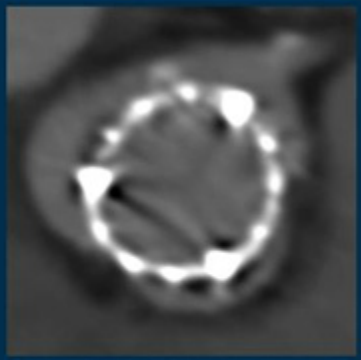
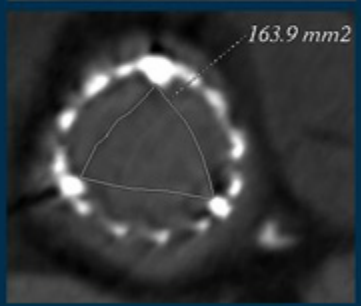
Double Oblique View



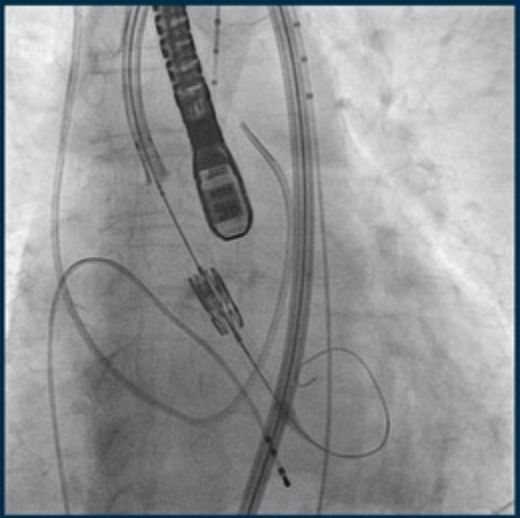


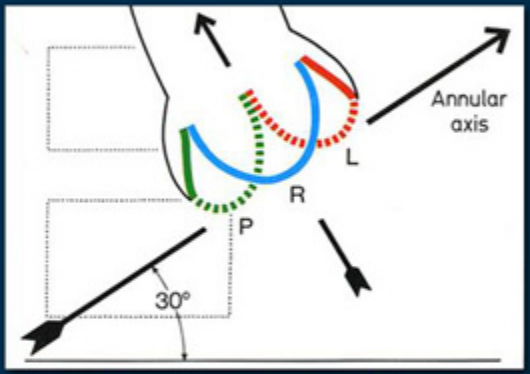


No Valve Migration, Fracture, Circumferentiality

Valve positioning
And
C-arm angle

Positioning of the Valve

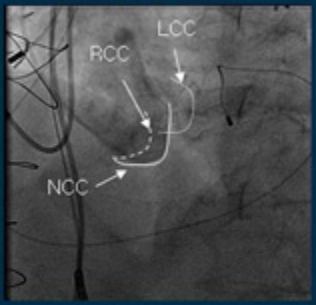




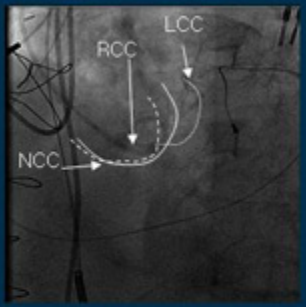
3 sinuses are visualized on 1 single line - perpendicularity

Selection of Fluoroscopic Projections

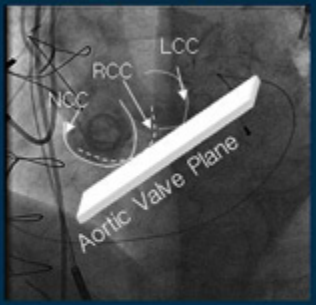
LAO 40 Cr 20



LAO 40 Cr 30



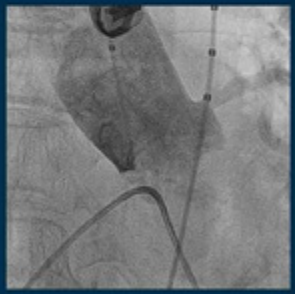
LAO 30 Cr 30



AP 0 CAU 5

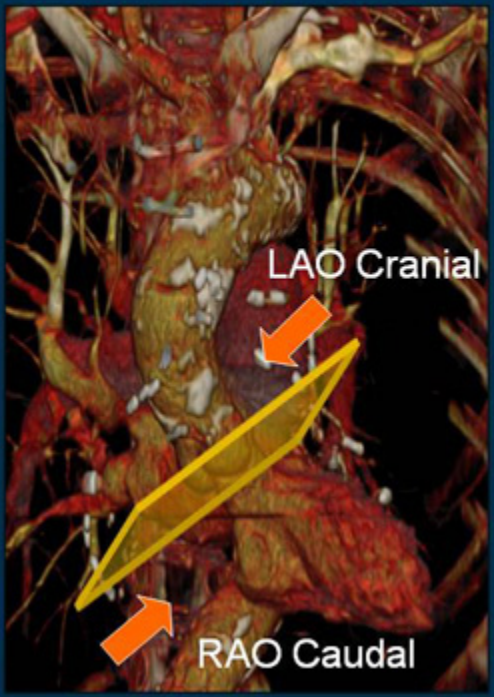
LAO 2 CAU 10

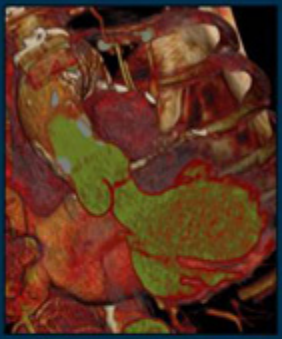
LAO 10 CAU 10

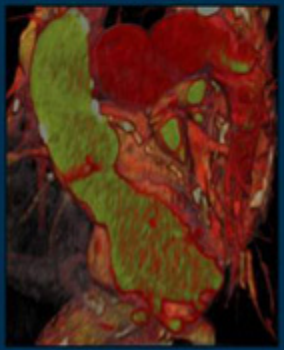


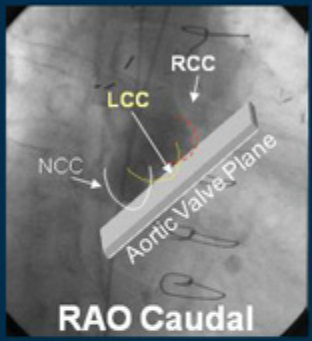
Three cusps in same plane

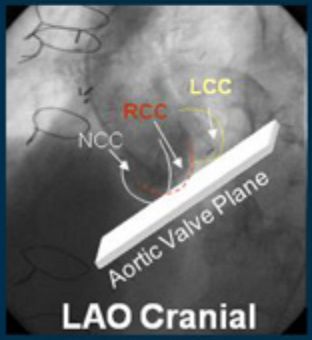
Aortic Valve Plane by CT Scan











DynaCT & CT co-registration

Siemens
Syngo iPilot

Philips
Heart Navigator

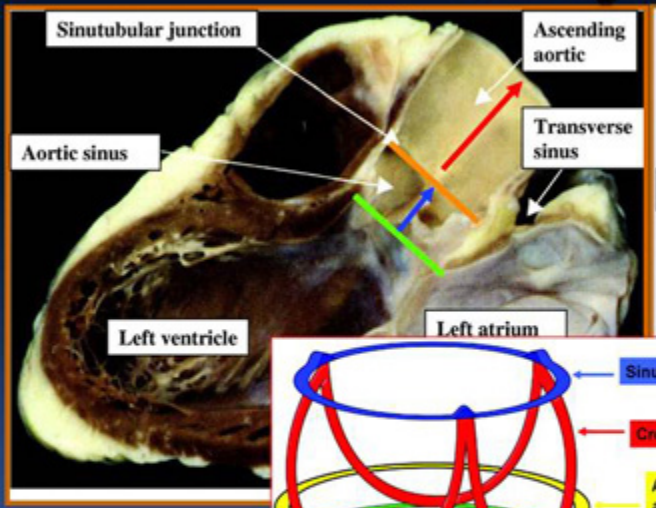
GE
Innova Vision Technology

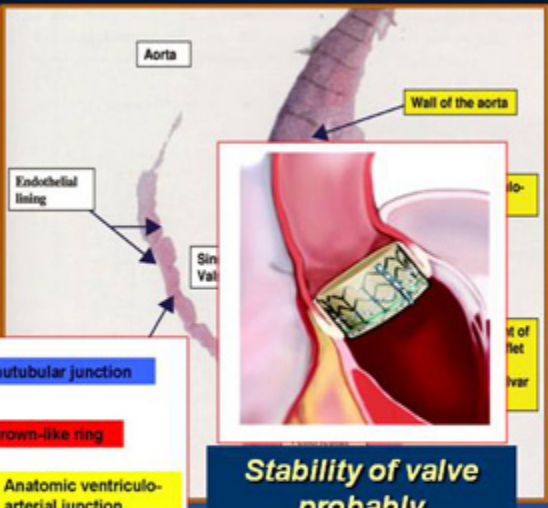
Annulus sizing

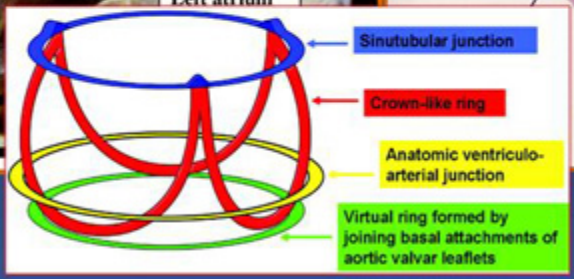
Aortic Annular Sizing

- Traditionally, annular measurements for TAVI rely upon by TTE, TEE, and angiography
- Discordance between modalities is not uncommon
- Based on the data and expert's instructions, Annulus size TTE < TEE < CT measurement

Anatomy of Aortic Valvar Complex





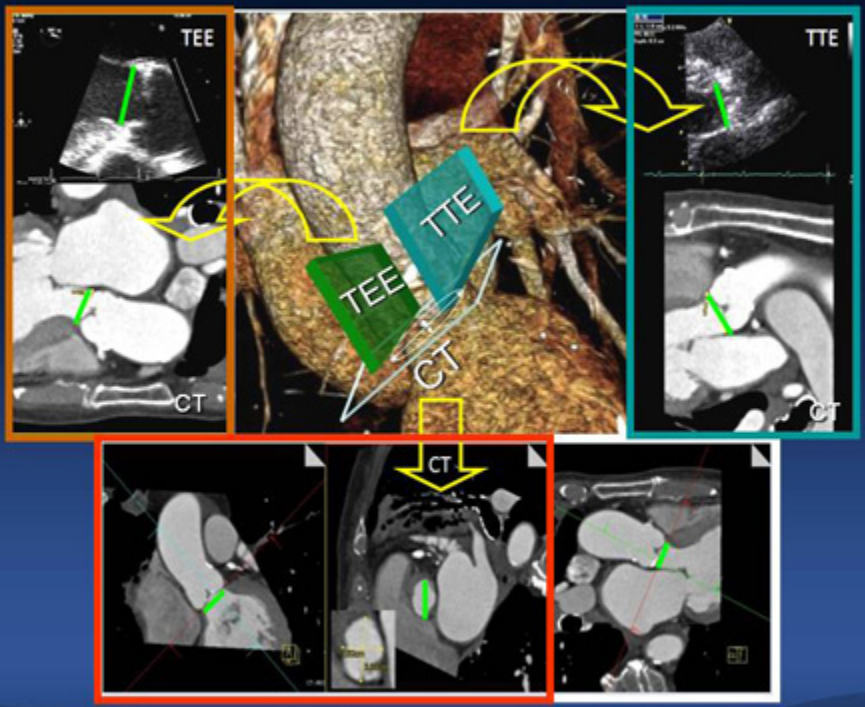


Stability of valve probably determined by the "virtual ring"

Aortic Root thus composed of 3 rings and one crown-like ring

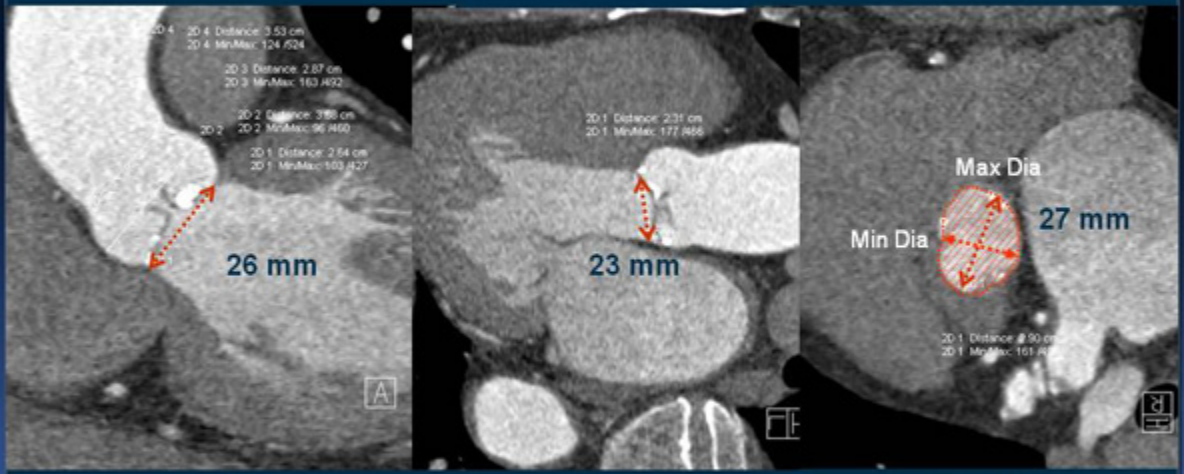
Piazza, N. et al. Circ Cardiovasc Interv 2008;1:74-81

What are we trying to measure?



Tuzcu et al, JACC, *2010* Topol L, et al. JACC imaging. *2008* Doddamani S, et al. Int J Cardiovasc imaging. *2009*

Aortic Annular Sizing:
Using MDCT



Coronal | Sagittal, 3 chamber | Dobule oblique

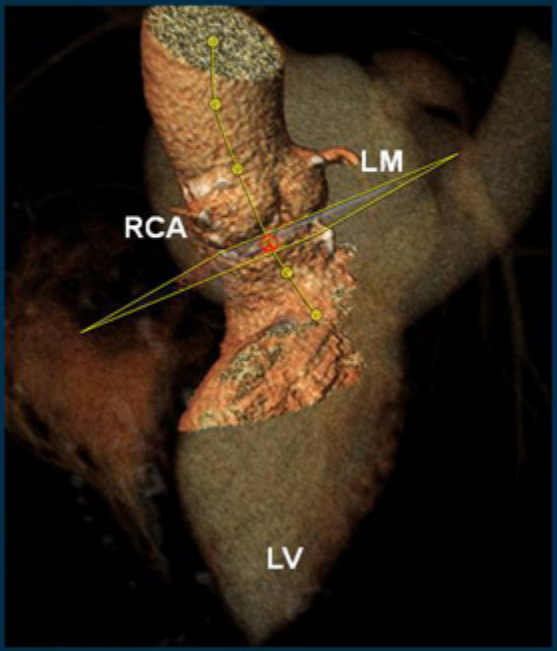
Basal Mean Diameter & Area Measurement of Basal ring (2* √ area/ ∏)

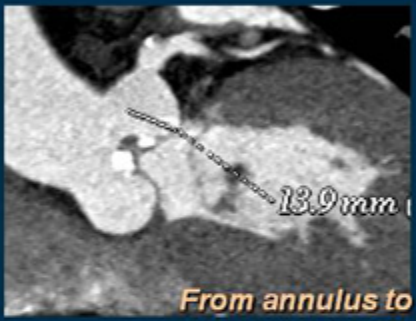
Gurvitch et al. JACC intervention. *2011;4:1235*

What to do with CT annular measurements currently?

- **Multidisciplinary approach** - team members from the interventional and surgical teams reviewing aortic annuli with the CT and echo teams
- Root geometry and annular configuration by CT affords the implanting physician greater understanding of the patient's anatomy and allows for a more individualized TAVI approach

Aortic root dimension and spatial relationship with surrounding structures





From annulus to LMCA

From annulus to RCA os

Fluoroscopic CT Image And Co-registration Image

Device Selection & Procedural Guidance

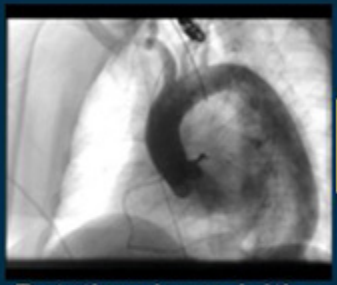
DynaCT & CT co-registration

Siemens
Syngo iPilot

Philips
Heart Navigator

GE
Innova Vision Technology

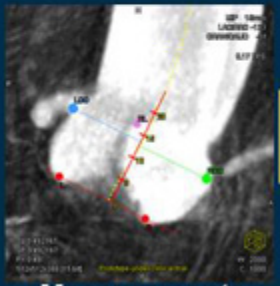
DynaCT & CT co-registration



Rotational acquisition

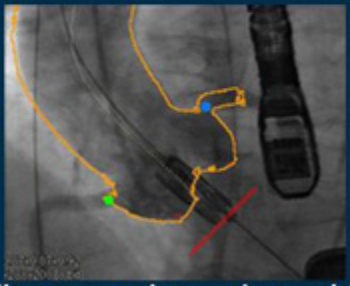
3D reconstruction

Segmentation & Landmark Detection



Measurements

Optimum angulation



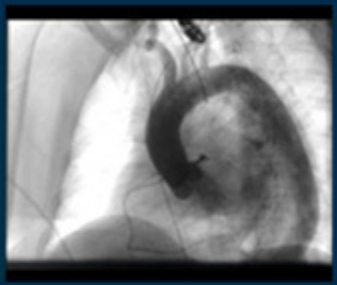
Fluoroscopic overlay guidance

DynaCT Image Acquisition with rapid pacing

- 5 sec rotation over 200°
- 15~25cc dye diluted to 75cc over 5 sec (1 sec X-ray delay)
- Injection via pigtail into aortic root
- With breathhold & rapid pacing

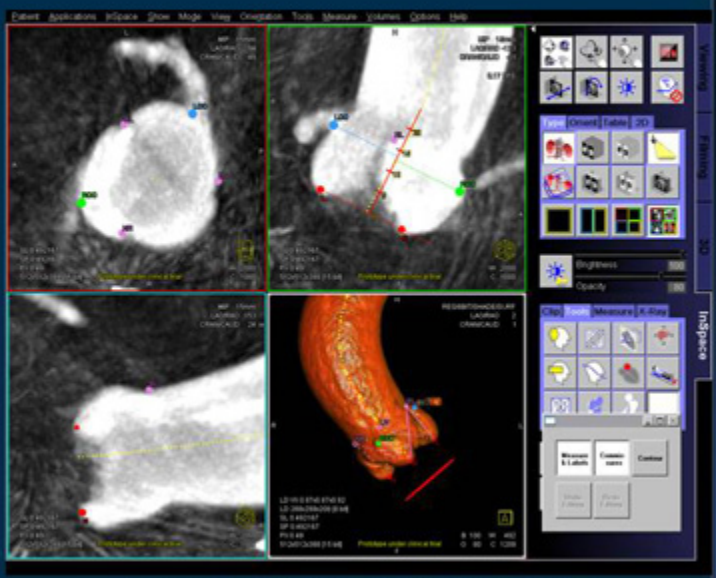
Courtesy Siemens Systems

Aortic Valve Guide workflow



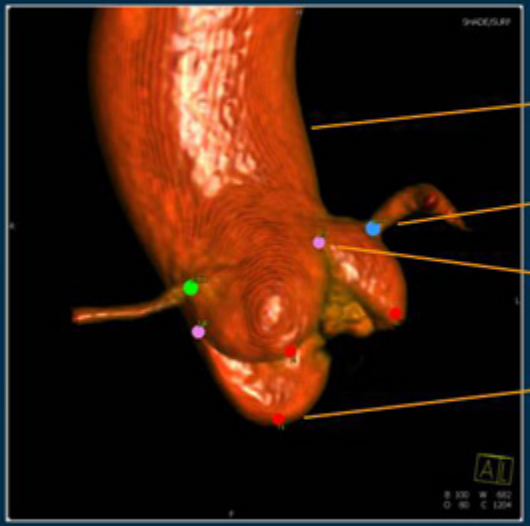
From end of 3D acquisition to in-room display of results

- Only 16 s
- Fully automatic
- High detection accuracy



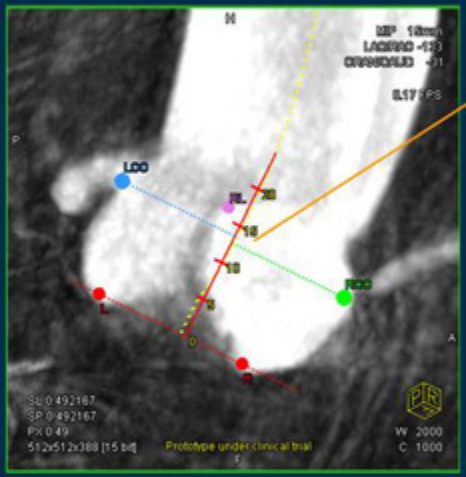
In-room display side-by-side with Live display

Detected landmarks

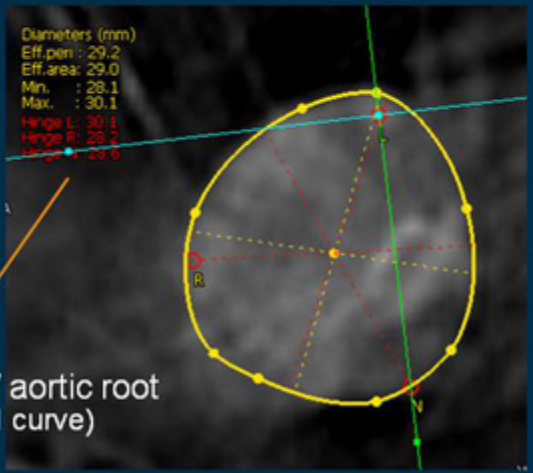


- Aortic root shape
- Coronary ostia
- Commissures
- Hinge points
  lowest cusp points
  (define annulus plane)

Measurements



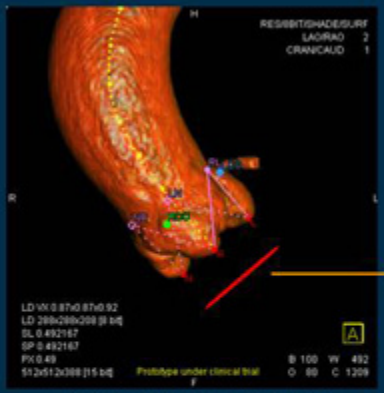
Distance of coronary ostia to annulus plane (defined by detected hinge points) via ruler



Diameters of annulus / aortic root (based on user-defined curve)

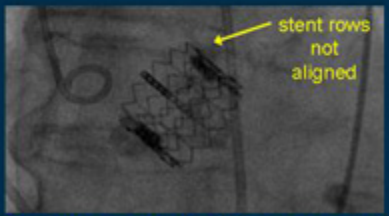
Optimum C-arm angulation

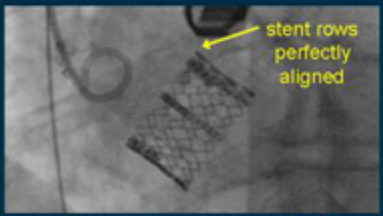
Non-perpendicular view



Perpendicular view
(circle degenerates to a line)

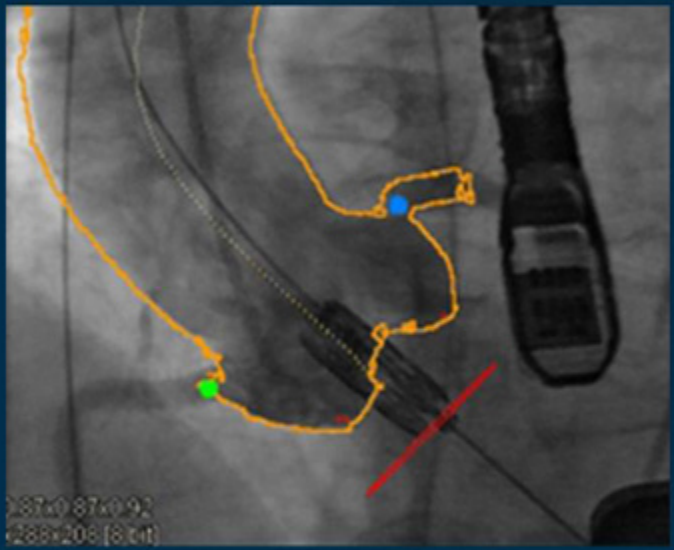
Perpendicularity circle
(parallel to annulus plane derived from hinge points)





C-arm angulation can automatically be adjusted based on virtual view

Fluoroscopic overlay



- Contour view improves visibility of fluoroscopic image
- Adjusts automatically to C-arm & table motion
- Manual correction for aortic root motion
  (not yet automatically)

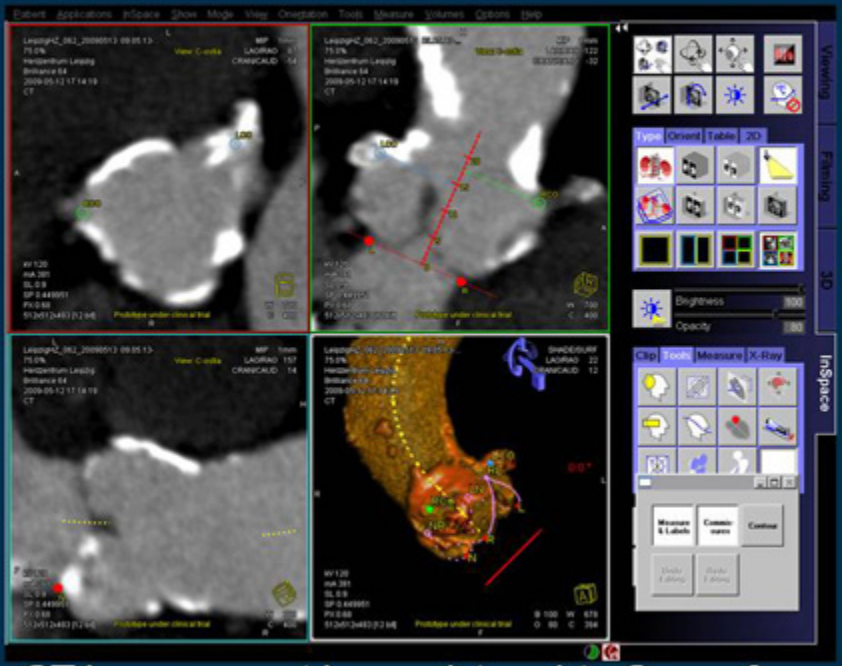
Valve deployment under DynaCT

Edwards SAPIEN

CoreValve

Courtesy by Alois Nöttling Siemens
Courtesy by Brockmann German Heart Center Munich

CT integration

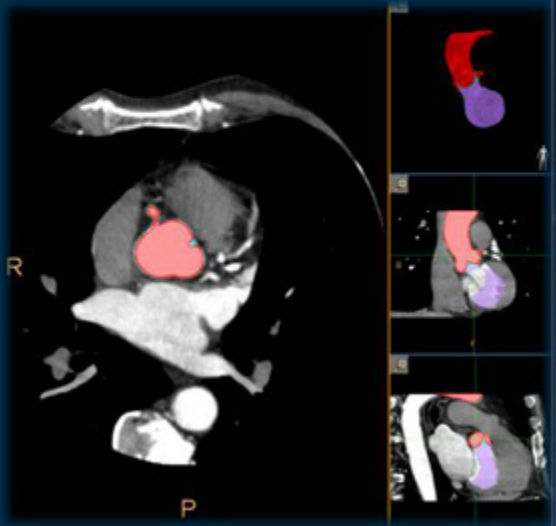


CT images must be registered to C-arm for overlay

Philips Heart Navigator

Step 1

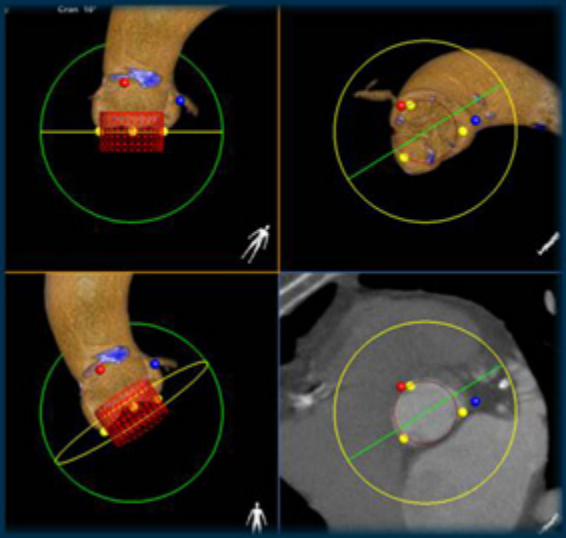
- Automatic segmentation of anatomical structures and landmarks from MSCT 3D dataset



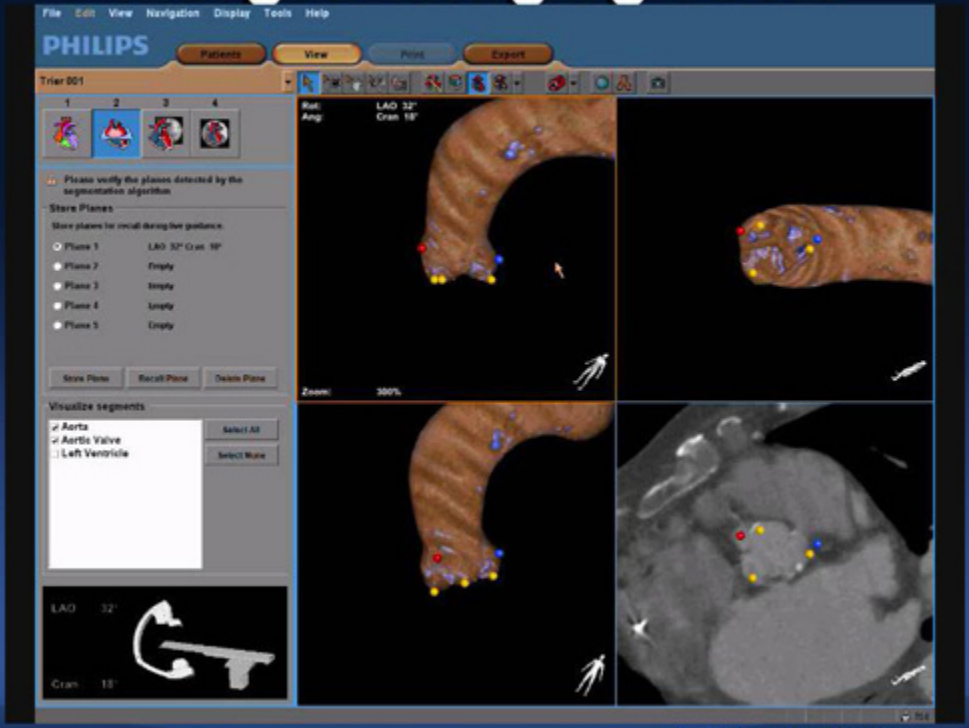
Philips Heart Navigator

Step 2

- Virtual device implantation
- Optimal view planning



Merged Imaging Tools

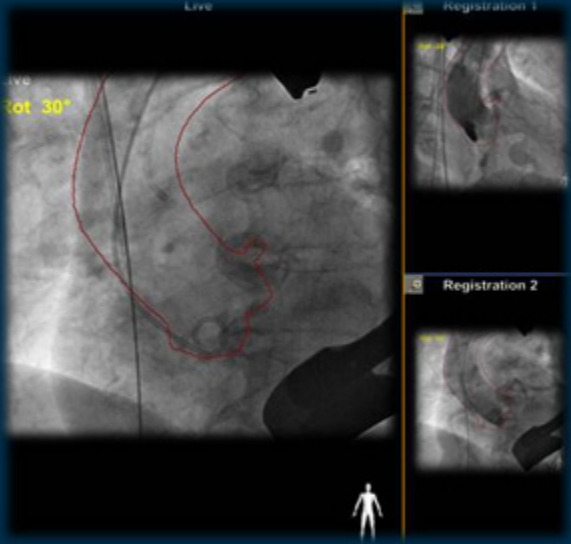


Courtesy by Philips

Philips Heart Navigator

Step 3

- Matching of 2D images with 3D dataset



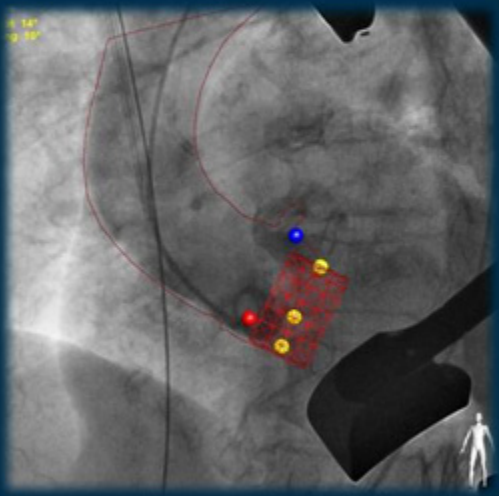
Registration

Courtesy by Philips

Philips Heart Navigator

Step 4:

- Automatic follow of overlay when changing C-arm projections



Valve Implantation

Courtesy by Philips

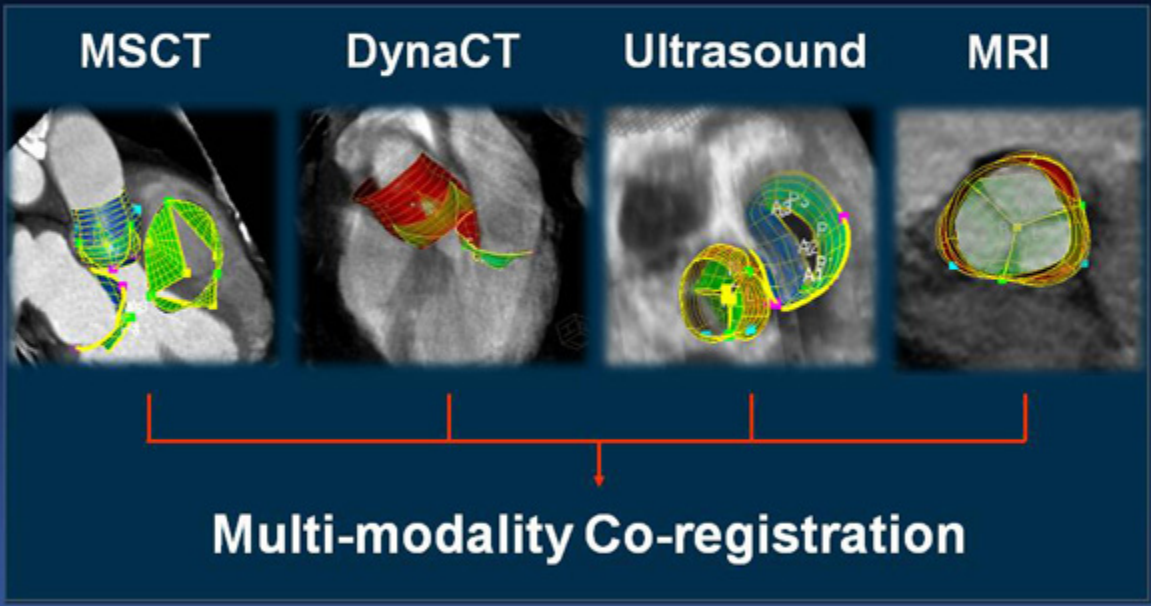
GE Innova Vision Technology

GE Innova Vision Technology

GE Innova Vision Technology

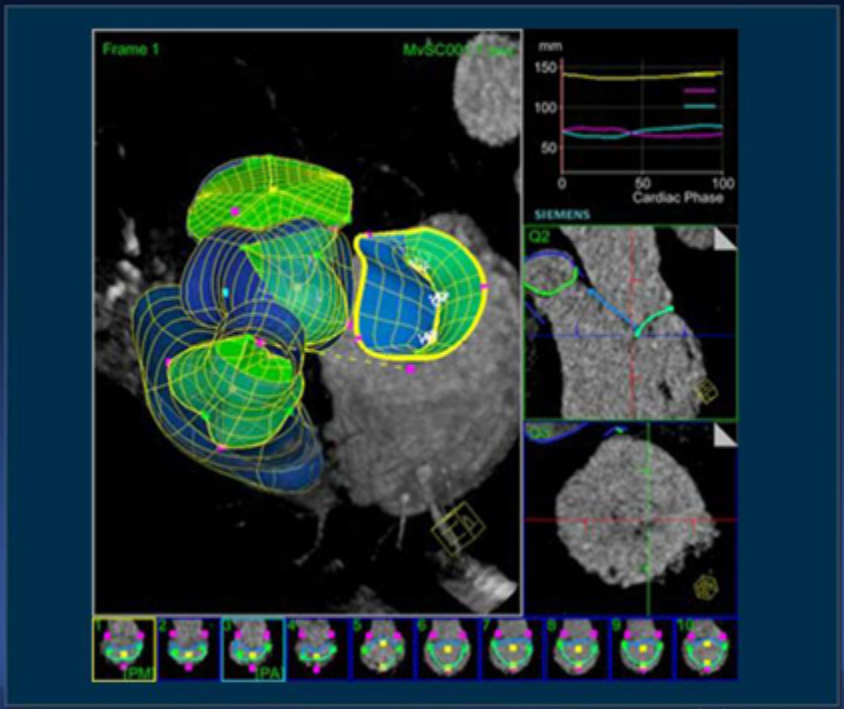
Multimodality Co-registration Image

3D/4D modeling



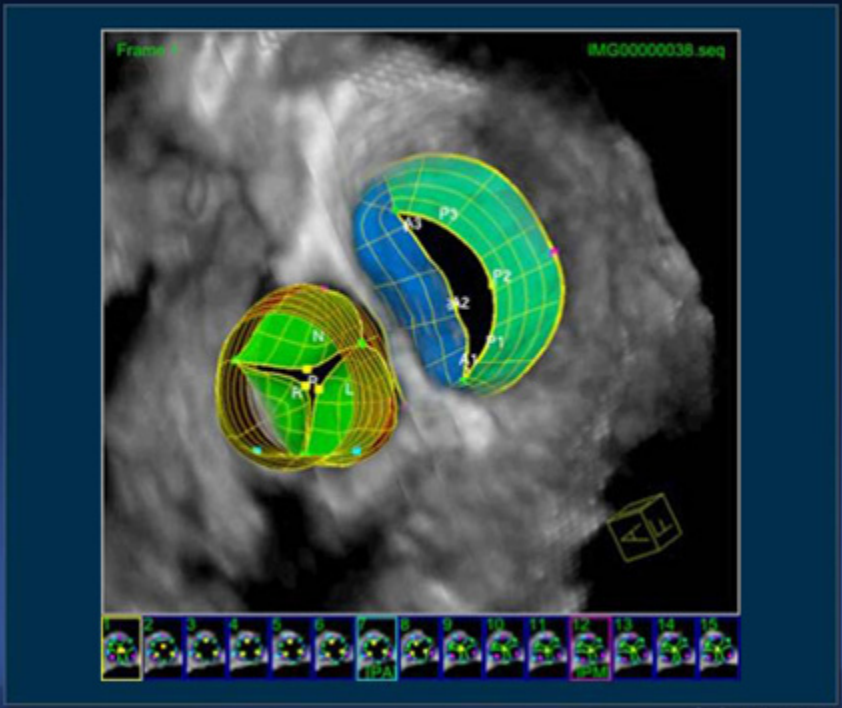
Courtesy of Razvan I. Ionasec, Siemens

MSCT 4D modeling



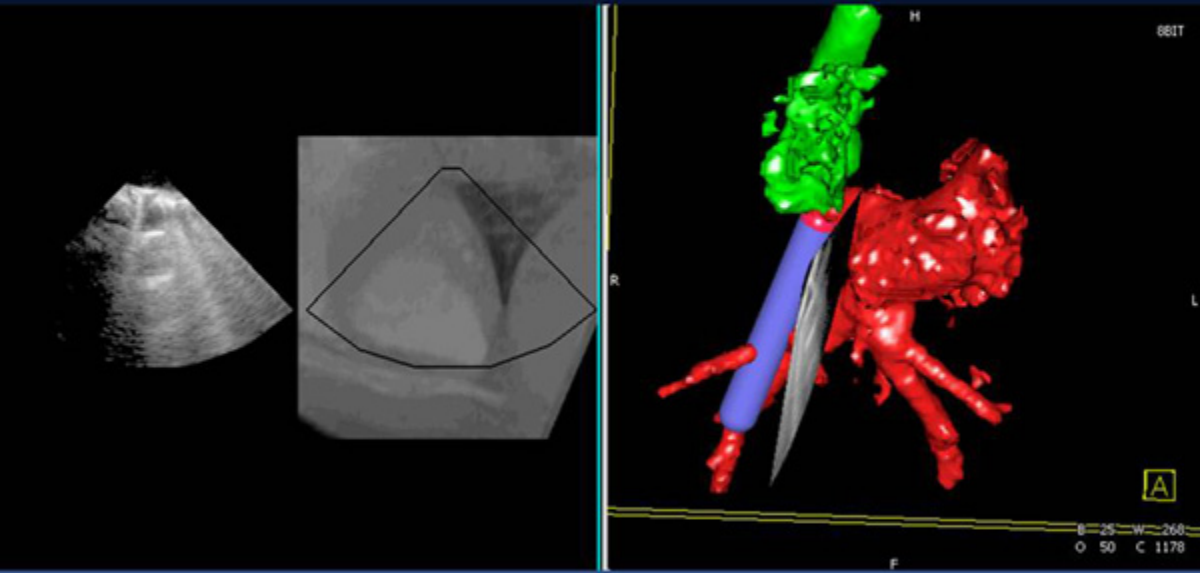
Courtesy of Razvan I. Ionasec, Siemens

TEE 3D modeling



Courtesy of Razvan I. Ionasec, Siemens

Echo – MSCT coregistration



CT-Coregistration & 4D CT

Strengths

- Easy imagination of complex AV structure
- Determine the best view of projection angle
- During the implantation, guide the valve position
- Measurements of distances from both ostia to annulus
- Additional information of correct valve sizing

CT-Coregistration & 4D CT

Limitation

- Motion compensation: Heart Beat, Breathing
- Technically, more need to develop
- Additional costs
- With developments of machine and software, above limitation might be solved…

Conclusions

- TAVI therapy has seen rapid advancements
- Imaging modalities also showed more development, especially CT
- With development of device technology and using the multiple imaging modalities, TAVI therapy will be more safe, comfortable, and expand the indication in near future
- Fluroscopic CT, CT or Multimodality-Coregistration have diverse development and successfully can guide the procedure