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Further Development of Cardiac CT in Interventional Cardiology

TCTAP 2012

Seoul, Korea

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Prevalence of significant peripheral artery disease in patients evaluated for percutaneous aortic valve insertion: Preprocedural assessment with multidetector computed tomography

Vikram Kurra, MD,[a,b] Paul Schoenhagen, MD,[a,b] Eric E. Roselli, MD,[a] Samir R. Kapadia, MD,[a] E. Murat Tuzcu, MD,[a] Roy Greenberg, MD,[a] Mateen Akhtar, MD,[a] Milind Y. Desai, MD,[a,b] Scott D. Flamm, MD,[a,b] Sandra S. Halliburton, PhD,[b] Lars G. Svensson, MD,[a] and Srikanth Sola, MD[a,b]

	Mean luminal diameter (mm ± SD)		
Arterial segment (mm)	**PAD group (n = 35)**	**No-PAD group (n = 65)**	***P* value (PAD vs no-PAD)**
Infrarenal abdominal aorta			
Right common iliac artery			
Right external iliac artery			
Right common femoral artery			
Left common iliac artery			
Left external iliac artery			
Left common femoral artery			

PAD, Peripheral arterial disease; *SD*, standard deviation.

J Thorac Cardiovasc Surg 2009;137:1258-64

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	Mean luminal diameter (mm ± SD)		
Arterial segment (mm)	**PAD group (n = 35)**	**No-PAD group (n = 65)**	***P* value (PAD vs no-PAD)**
Infrarenal abdominal aorta	15.2 ± 2.6	17.2 ± 2.9	.02
Right common iliac artery	9.4 ± 1.8	11.3 ± 1.5	.01
Right external iliac artery	7.1 ± 1.1	9.2 ± 0.9	.01
Right common femoral artery	7.3 ± 1.2	9.3 ± 0.9	<.001
Left common iliac artery	9.4 ± 1.6	10.9 ± 1.4	.03
Left external iliac artery	7.4 ± 0.9	9.2 ± 1.1	.001
Left common femoral artery	7.5 ± 1.1	9.2 ± 0.9	.01

PAD, Peripheral arterial disease; *SD*, standard deviation.

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Variable	PAD group (n = 35)	noPAD group (n = 65)	*P* value (PAD vs no-PAD)
Infrarenal AAA (>3.5 cm)			
Infrarenal aorta < 12 mm			
Circumferential calcification aortic bifurcation (>60%)			
Circumferential calcification iliac bifurcation (>60%)			

PAD, Peripheral arterial disease; *AAA*, abdominal aortic aneurysm. *By definition

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Variable	PAD group (n = 35)	noPAD group (n = 65)	*P* value (PAD vs no-PAD)
Infrarenal AAA (>3.5 cm)	2 (6%)	3 (4%)	.8
Infrarenal aorta < 12 mm	6 (17%)	0 (0%)	.22
Circumferential calcification aortic bifurcation (>60%)	7 (20%)	5 (8%)	.01
Circumferential calcification iliac bifurcation (>60%)	12 (34%)	0 (0%)*	.2

PAD, Peripheral arterial disease; *AAA*, abdominal aortic aneurysm. *By definition

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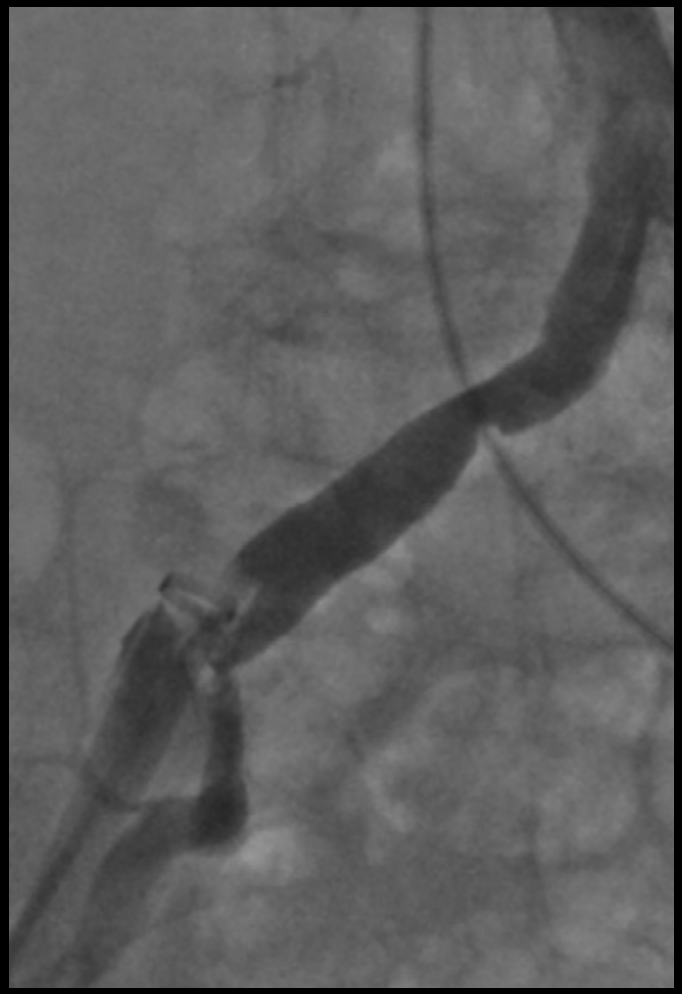
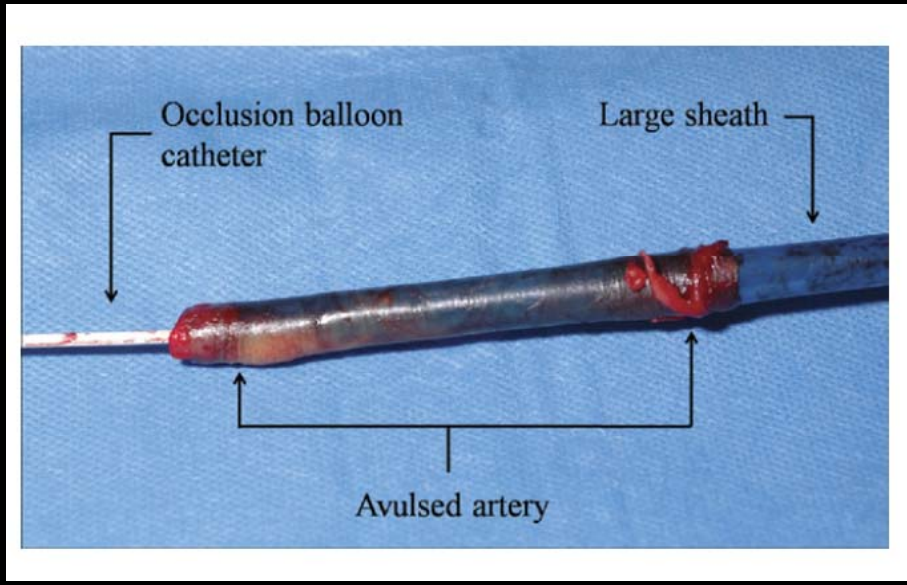
Risks of TAVI Access/Deployment





- Unable to deliver or deploy
- Dissection
- Embolism
- Entrapment/Avulsion

Masson et al JACC Intrv 2009 2:811-20

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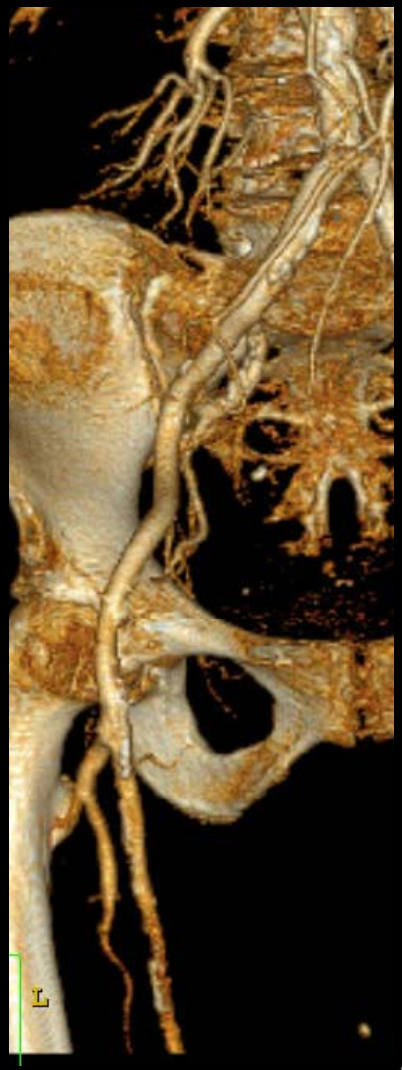
4 Primary Reasons for Failure

- Insufficient caliber
- Calcification
- Tortuosity
- Plaque
- Incidental findings: aneurysms; previous dissections

- CT can play a strong role in identifying potential problems



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Standard CTA Aorta Exam

- Arch to mid-thigh (extend to subclavian arteries for TAVI patients)
- Non-con followed by con-enhanced
- Helical, ungated CT
- Pro:
  - Fast, familiar, full coverage of aorta
  - Normal peripheral IV access
- Con:
  - No gating: artifact of root
  - Large contrast volume (100-120 mL)

Alternative Exams

- Dynamic gating: (on) through chest and (off) through abdomen/peripheral
  - Good option if contrast volume not a concern
- Full aorta non-contrast with con-enhanced scan dedicated to iliac/femoral
  - Reduces contrast volume
- Intra-aortic contrast injection and dedicated iliac/femoral scan
  - Lowest possible contrast volume
  - Obtain critical lumen calibers in iliacs/femorals

Ultra-Low Dose Iliofemoral CTA

- Consecutive patients being evaluated for percutaneous valvular intervention requiring large bore arterial access
- Cardiac catheterisation with a 6 Fr femoral sheath
  - DSA of iliac arteries in antero-posterior projection
    - single injection of 30cc contrast into abdominal aorta via pigtail catheter
- Pigtail catheter left in situ in infra-renal abdominal aorta
  - connected to heparinized saline and secured

- Patient transferred to CT suite
- CT next to Cardiac Cath labs

Methods

CT Imaging Protocol (1)

- Philips iCT 256 slice scanner
- Survey

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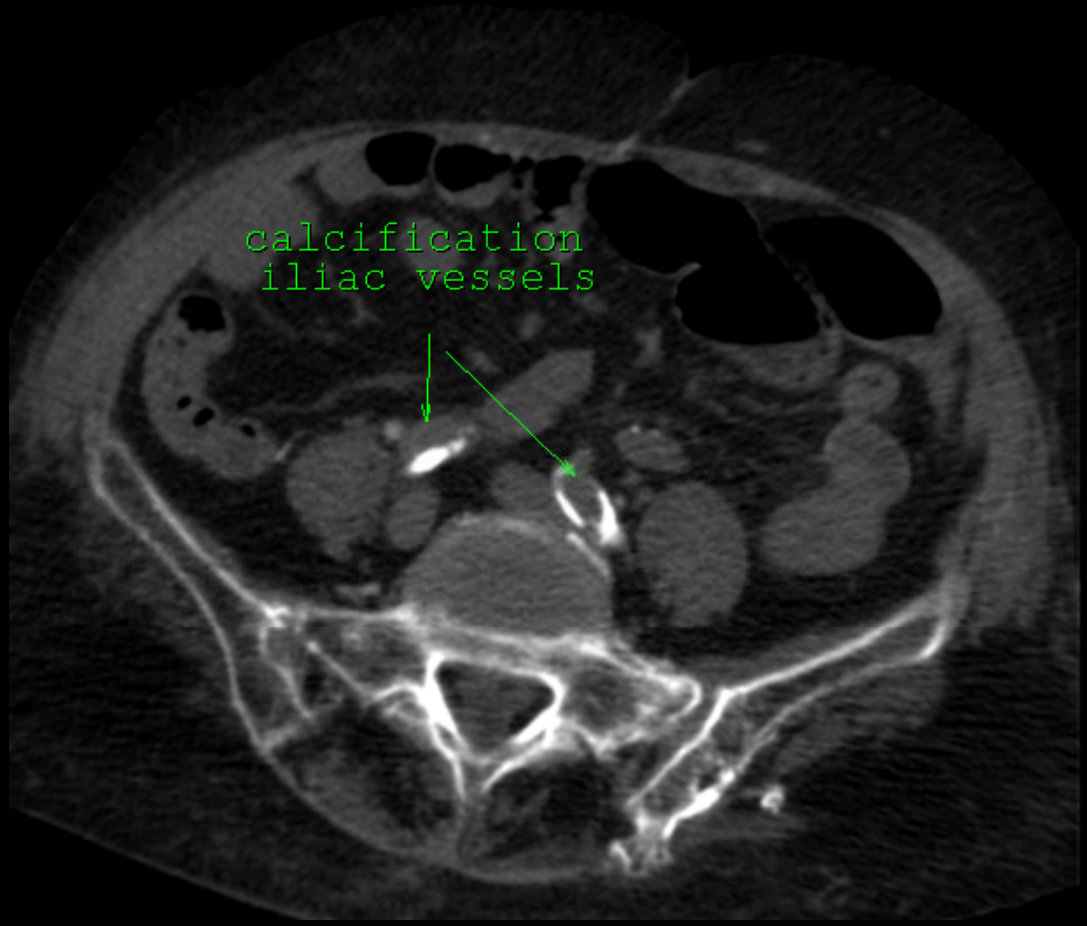
Methods

CT imaging (2)

- non contrast scan of chest abdomen and pelvis

- calcification
- confirmation of catheter position



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Methods

CT Imaging Protocol (2)

Contrast Enhanced Scan

- 1:3 to 1:4 dilution contrast to saline mixture (Isovue 370)
- 40 cc of total volume (10-12 cc of contrast) injected at 4 cc/second via pigtail catheter
- 9 sec scan delay
- helical ungated CT from mid-abdomen to mid thigh
  - 256 x 0.625 collimation, rotation time 0.75 seconds, pitch 0.64, 120 kV, 154 mAs, thickness 3 mm
- pigtail catheter removed while patient in CT suite
  - arterial sheath left in situ to be removed later

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Intra-aortic CTA

Joshi SB, Mendoza DD, Steinberg DH, Weissman G, Satler LF, Pichard AD, Weigold WG. JACC Imaging 2009;2:1404-11

- 37 pts undergoing TAVI (Edwards valve)
- Intra-aortic contrast injection via pigtail catheter after inv. coronary angio
- 10 mL contrast diluted in 30 mL saline

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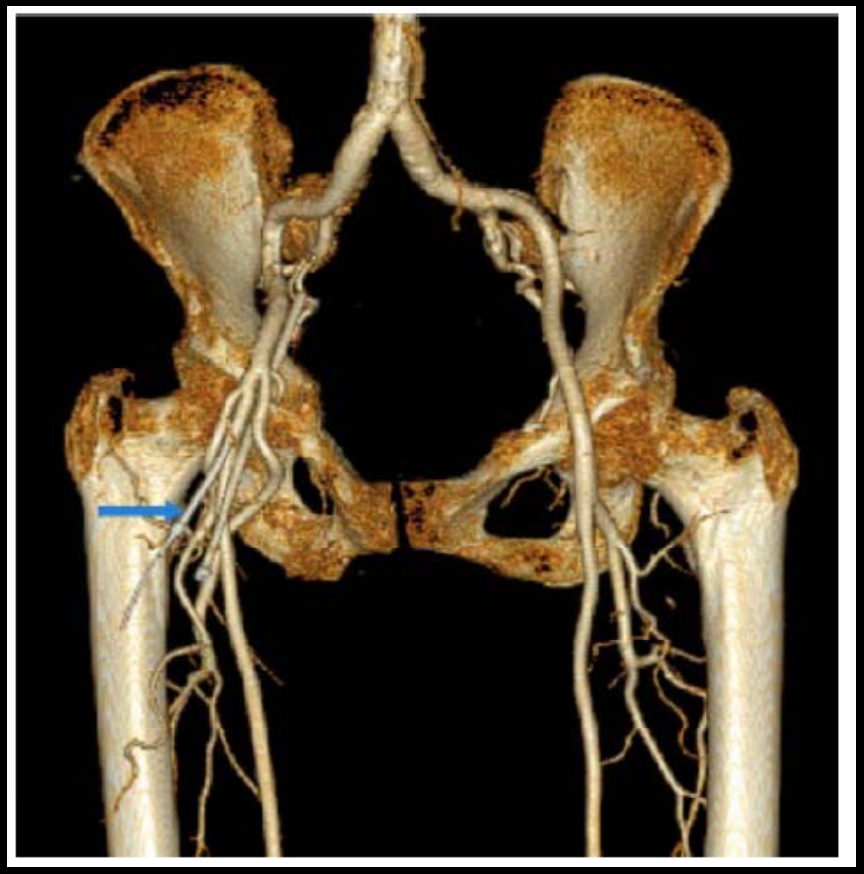
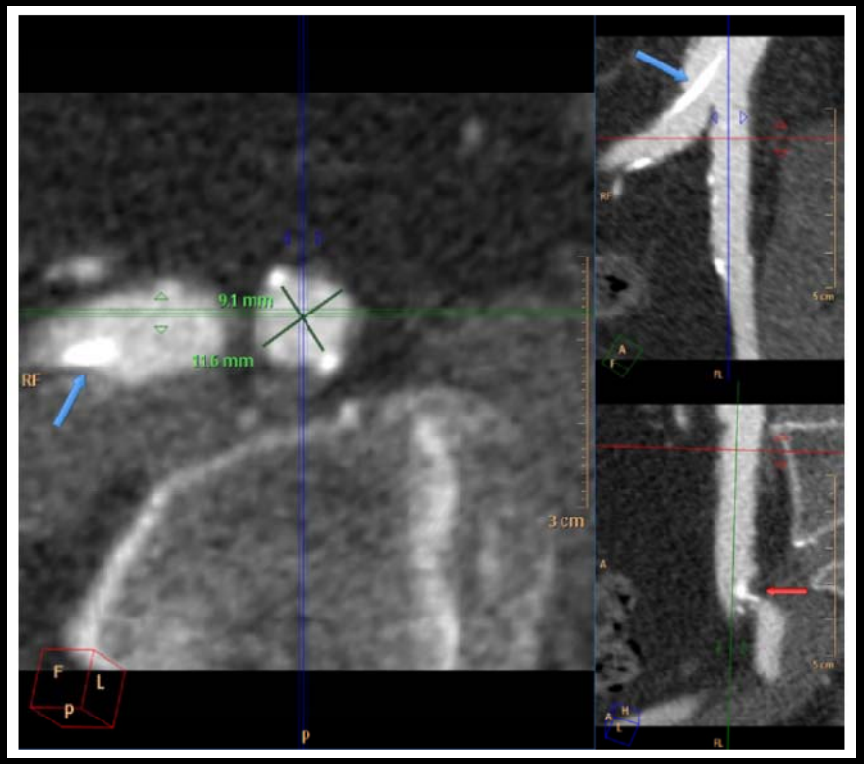
Intra-aortic CTA





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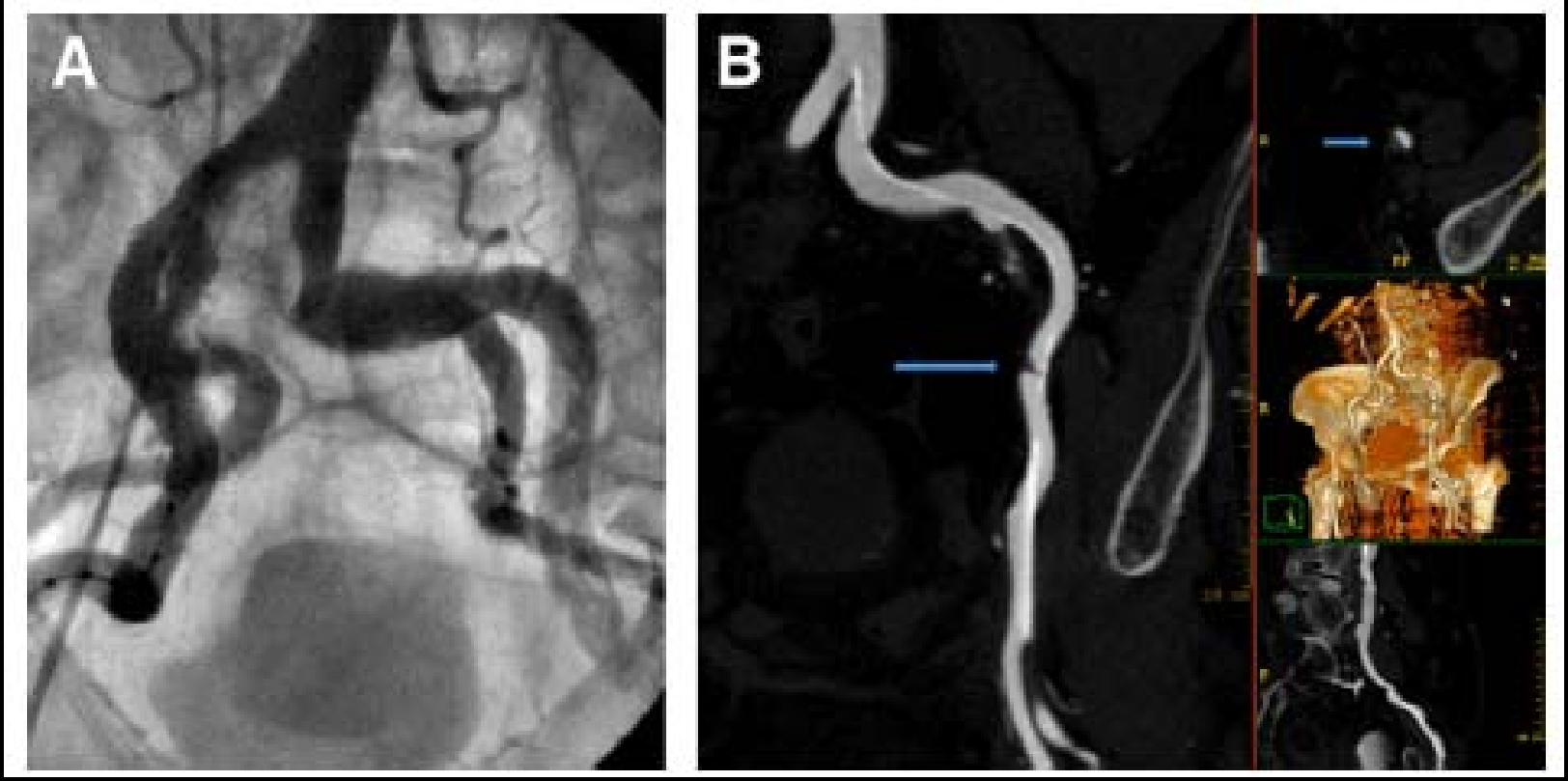
Focal arterial stenosis



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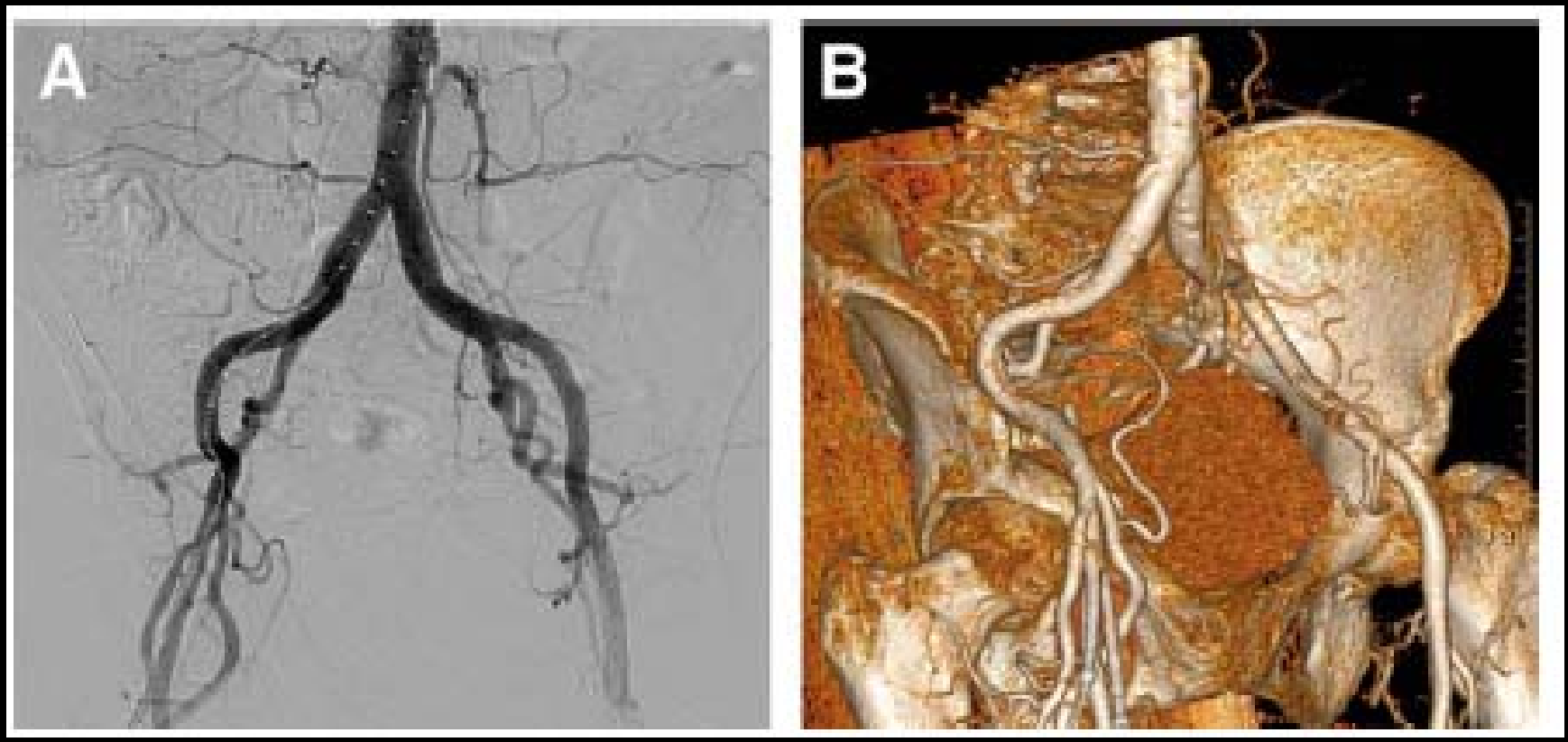
Tortuous course



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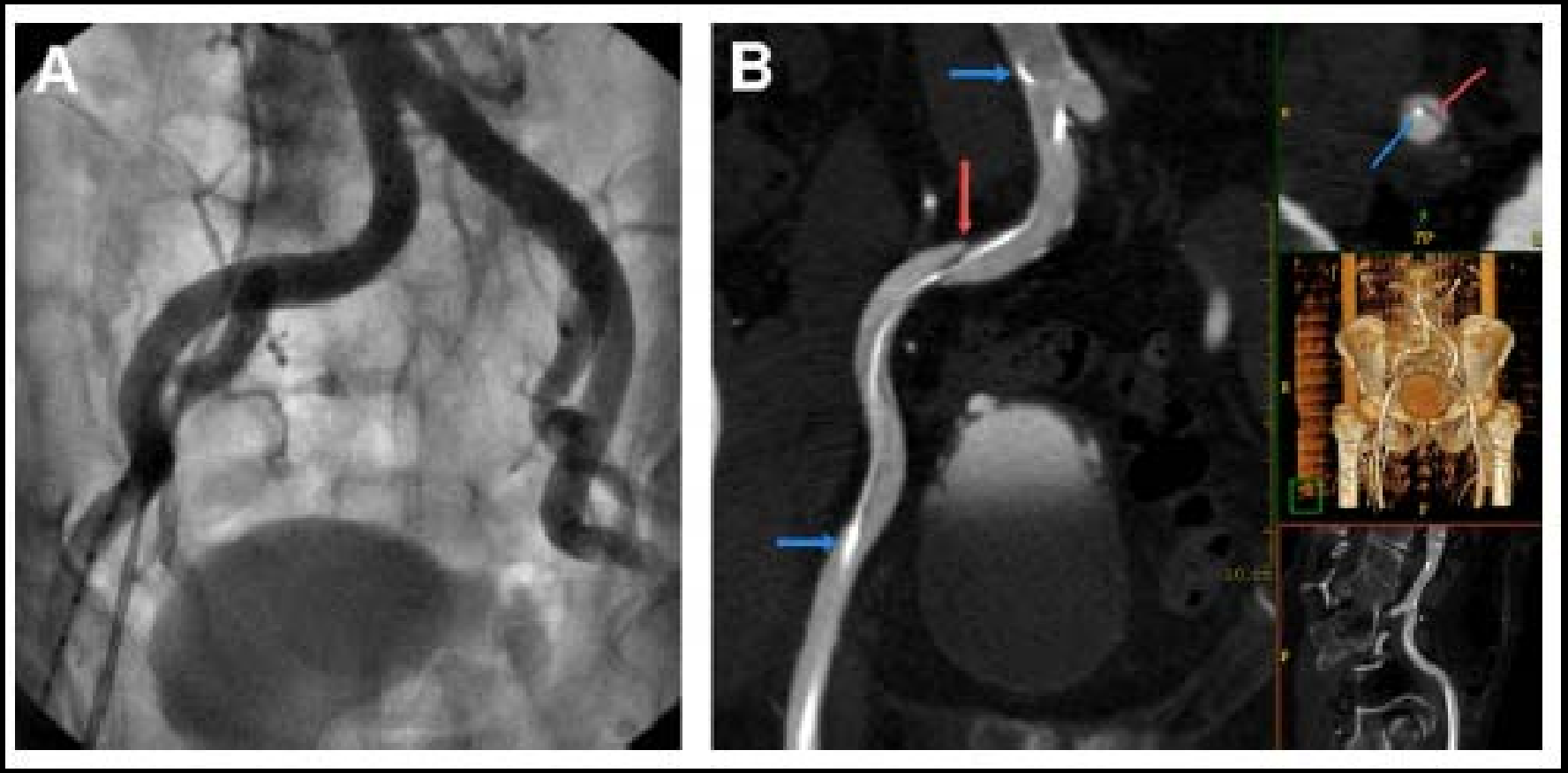
Arterial Dissection



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CTA and TAVI Contraindications

Table 1. Contraindications to Large-Bore Femoral Arterial Access As Assessed on Conventional and Computed Tomographic Angiography

	Severe Tortuosity	Circumferential Calcification	Diameter <7 mm	Arterial Dissection
CA	11	0	20	0
IA-CTA	13	3	28	1

CA = conventional angiography; IA-CTA = intra-arterial computed tomographic angiography.

- Compared to conventional angio, CTA reveals more of the factors that are associated with poor outcomes
- More sensitive tool

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Results (6)

Clinical Impact

- In 7 patients (26 %) CT angiography lead to cancellation of percutaneous intervention due either to confirmation or discovery of contra-indication
  - severe vessel tortuosity
  - stenosis
  - severe calcification

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Role of CT in TAVI

- Percutaneous AVR requires detailed understanding of annulus/root/leaflet/ST jxn anatomy & morphology
- Cardiac CT uniquely well suited to this task
  - 3D dataset
  - Infinite manipulation / rotation
  - Excellent spatial resolution (< 0.5 mm)
  - Advanced measurement tools

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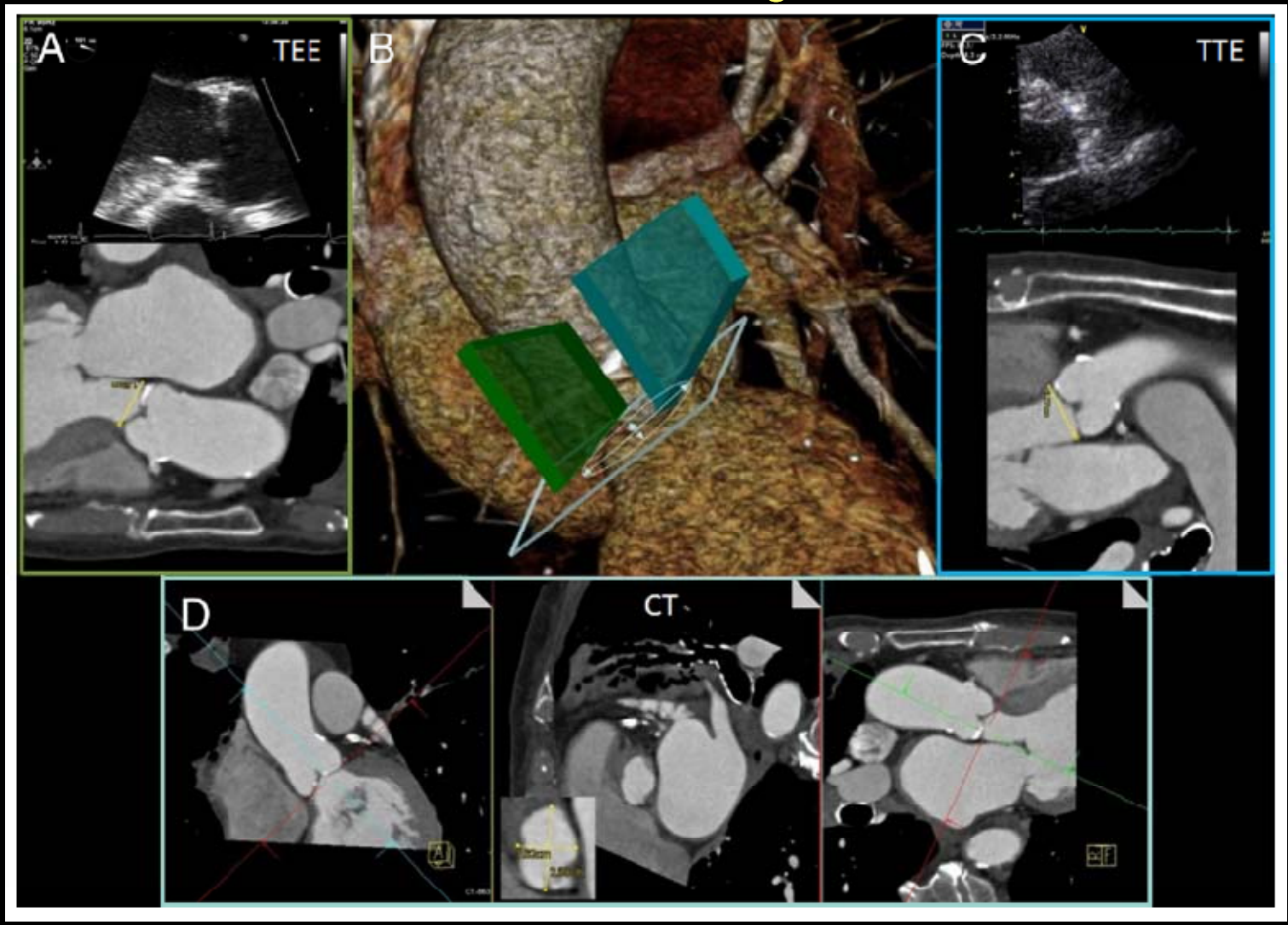
Caveat

- One limitation: lack of standardization of measurement method
  - CT measurement methodology requires method of image DISPLAY, as well as actual measurement method
  - Conflict between OPTIMAL CT DISPLAY method, and display that parallels that of gold standard
    - Same problem in coronary CTA
    - One approach: make a CT look like an aortogram

Multiple measures from multiple modes

Which one is “right”?



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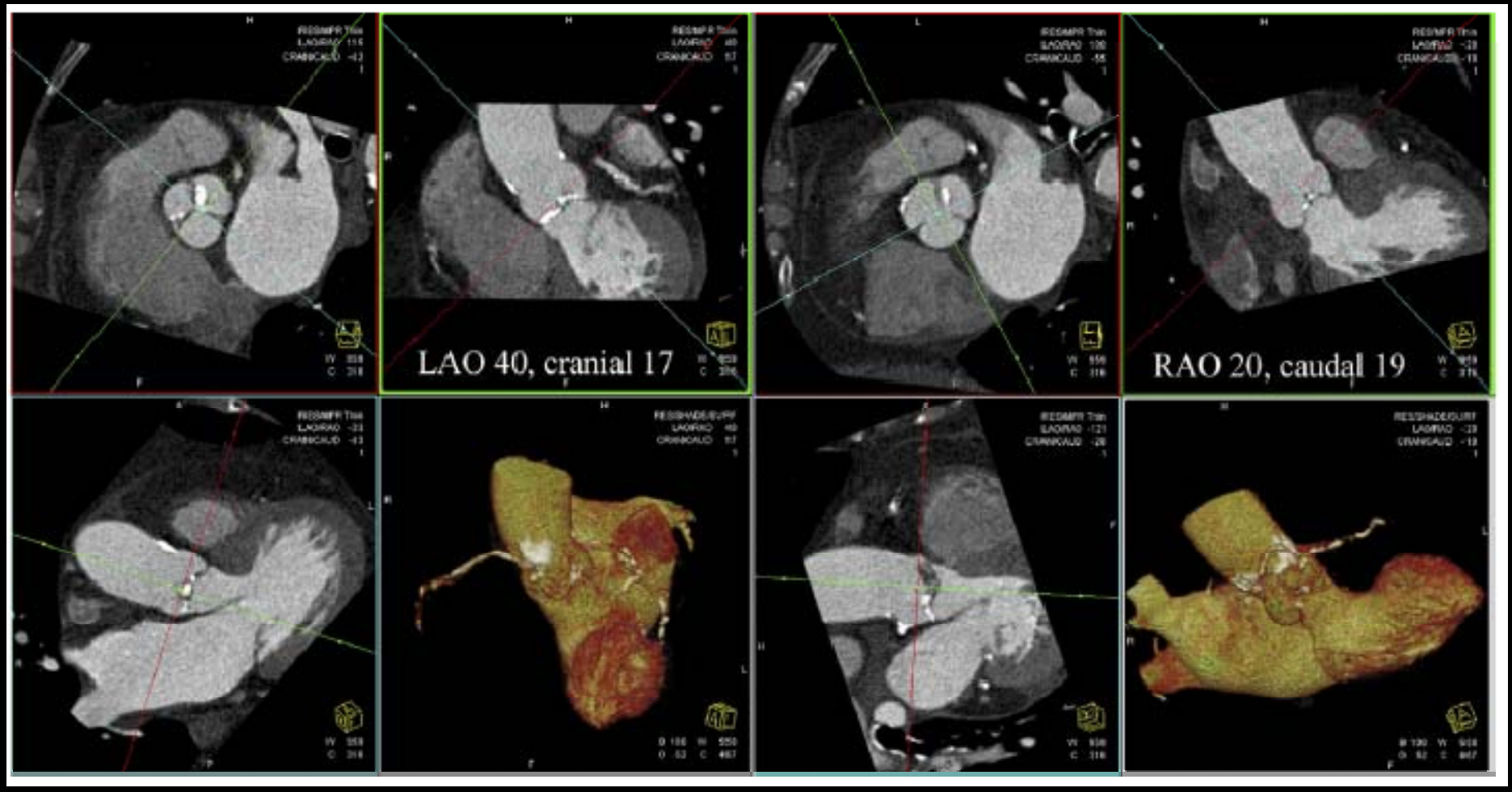
Aortic Root Measurement: CTA vs Aortography
Kurra V et al. JACC Intv 2010;3:105-113



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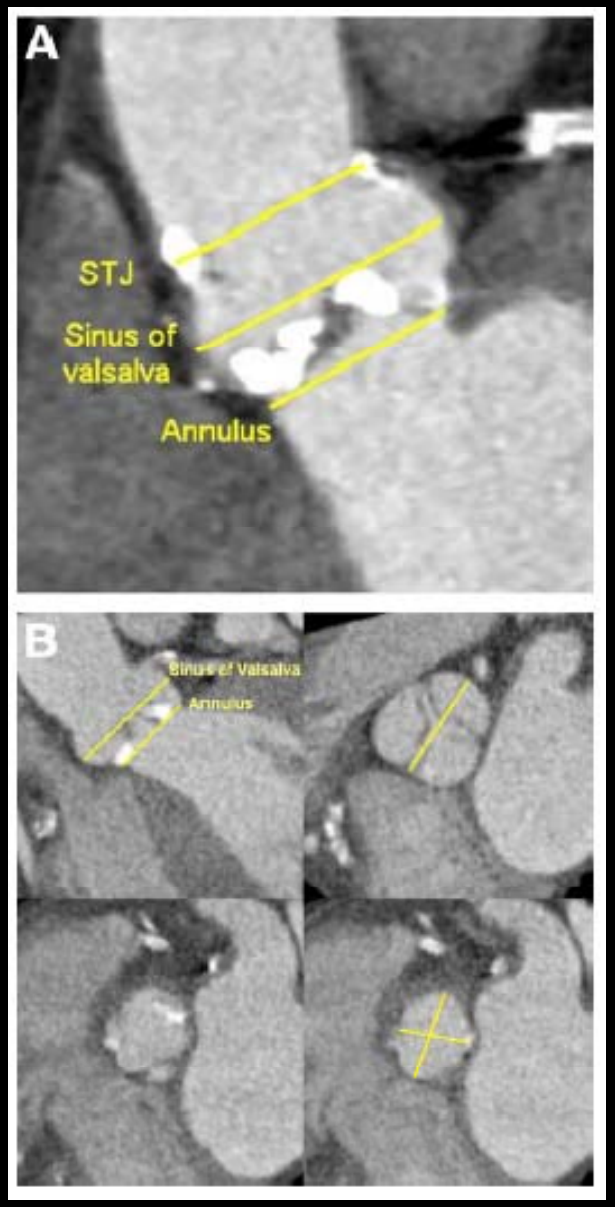
Aortic Root Measurements: MDCT



- Standard measurements (A)
- Measurements from cross sectional imaging (B)
- N=40

Table 4. Comparison of Annulus, Sinus of Valsalva, and STJ Dimensions in Matched LAO/Cranial and RAO/Caudal Planes Between X-Ray and MDCT Angiography

	LAO CT	LAO Angiography	p Value (95% CI*)
Annulus, cm	2.4 ± 0.3	2.3 ± 0.3	0.052 (–0.1 to 0.2)
Sinus of Valsalva, cm	3.3 ± 0.3	3.5 ± 0.6	0.04 (–0.4 to 0.1)
STJ, cm	2.5 ± 0.3	2.8 ± 0.5	<0.0001 (–0.5 to 0.1)
	RAO CT	**RAO Angiography**	
Annulus, cm	2.2 ± 0.3	2.4 ± 0.3	0.029 (–0.2 to 0.01)
Sinus of Valsalva, cm	3.2 ± 0.4	3.4 ± 0.5	0.01 (–0.3 to 0.04)
STJ, cm	2.5 ± 0.3	2.8 ± 0.4	<0.0001 (–0.4 to 0.1)

Data obtained using paired *t* test. *Describes the 95% CI of the difference between the means of variables.

Abbreviations as in Tables 2 and 3.

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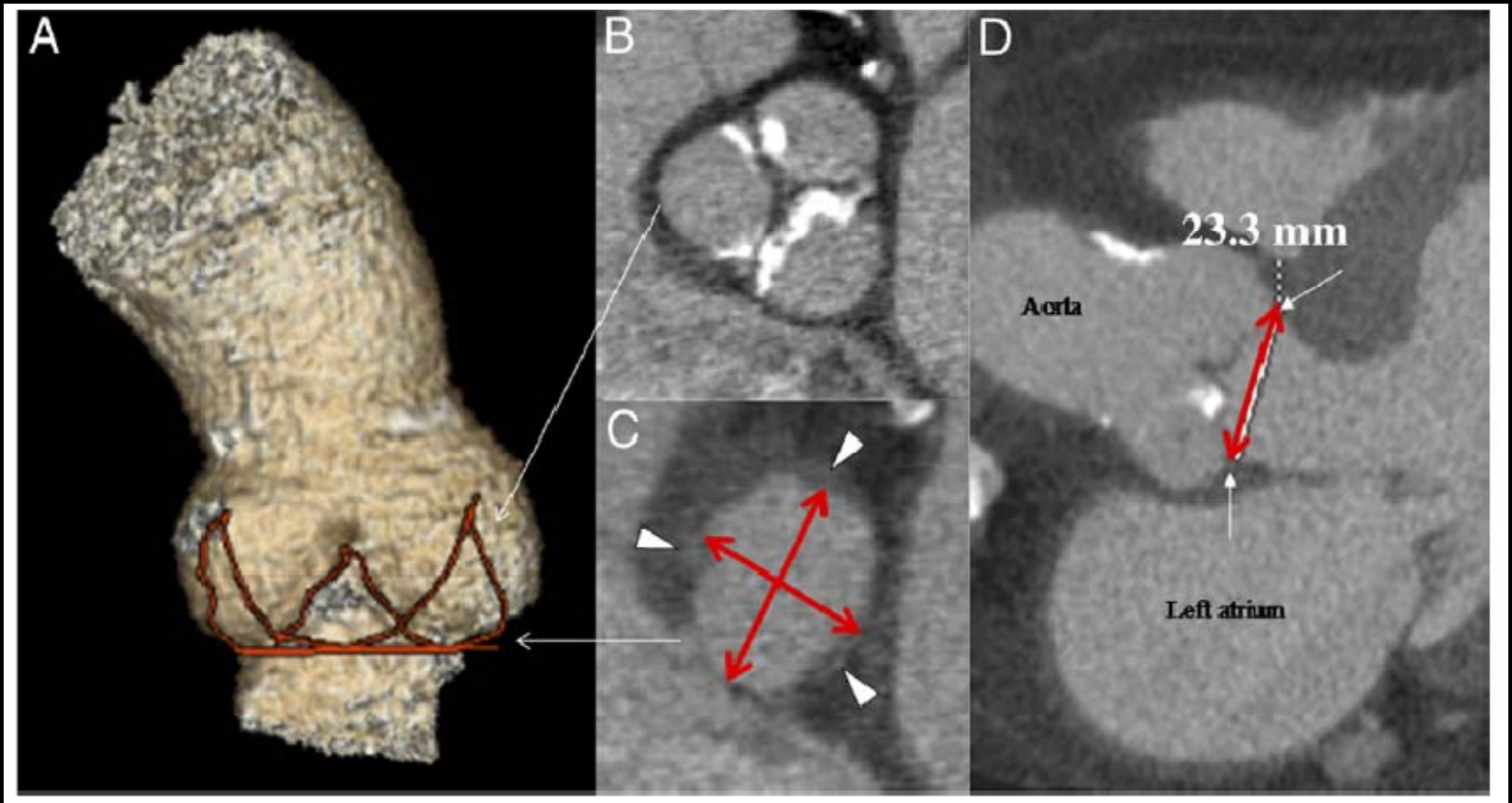
Multimodality assessment of aortic annulus diameter

Messika-Zeitoun D et al. JACC 2010;55:186-94



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Methods

- TTE and TEE
- Annulus diameter standard method, midsystole, PLAX (TTE) or 120-140 LAX (TEE), averaged over 3-5 beats.
- 64 MDCT
- 2 CT measurement methods:
  - Short and long axis of short axis view of annulus
  - 3 chamber echo mimic view

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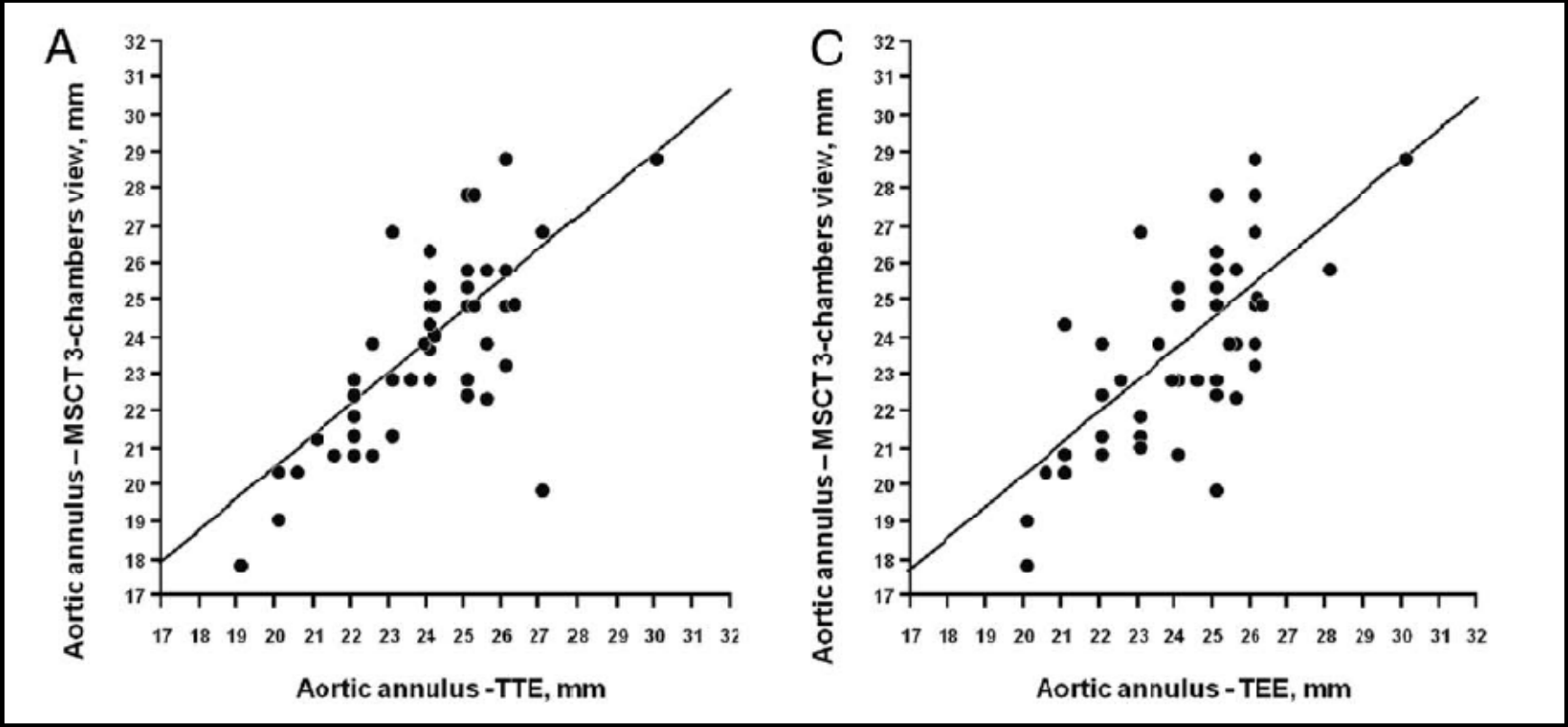
Correlation
n=45



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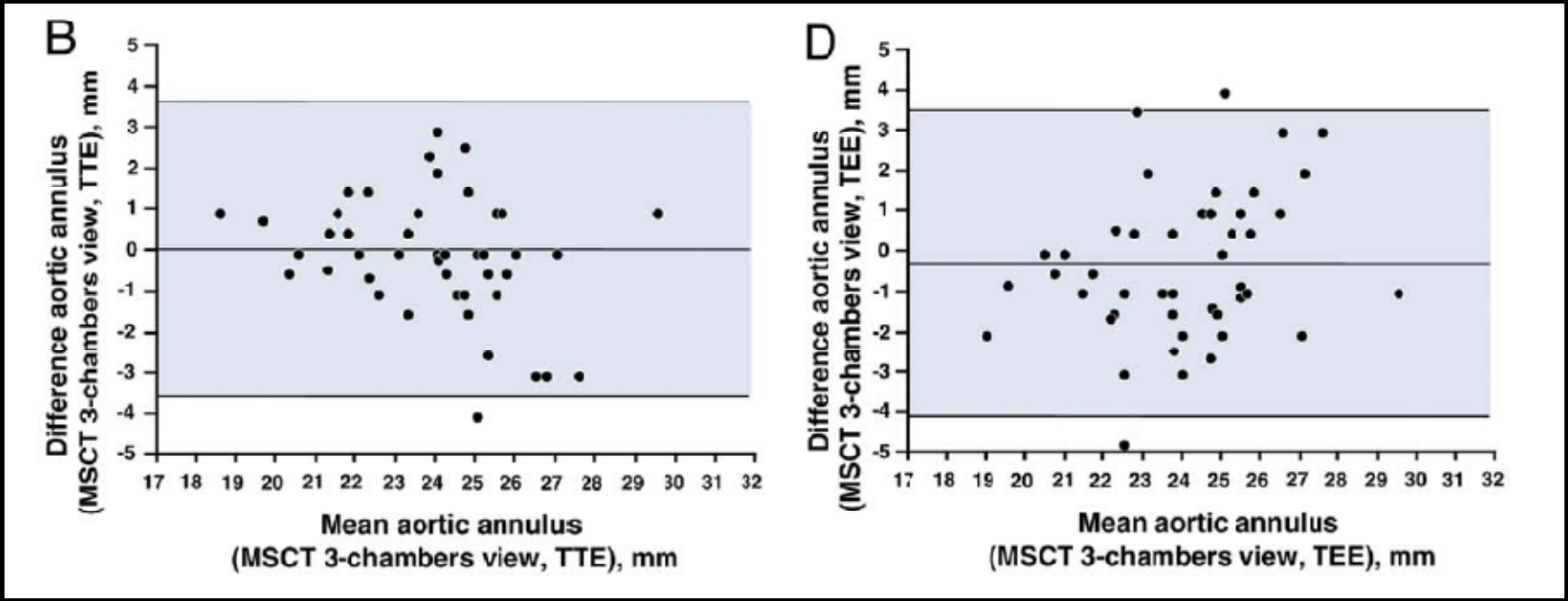
Accuracy
n=45



Minimal bias
95% CI +/- 3 to 4 mm

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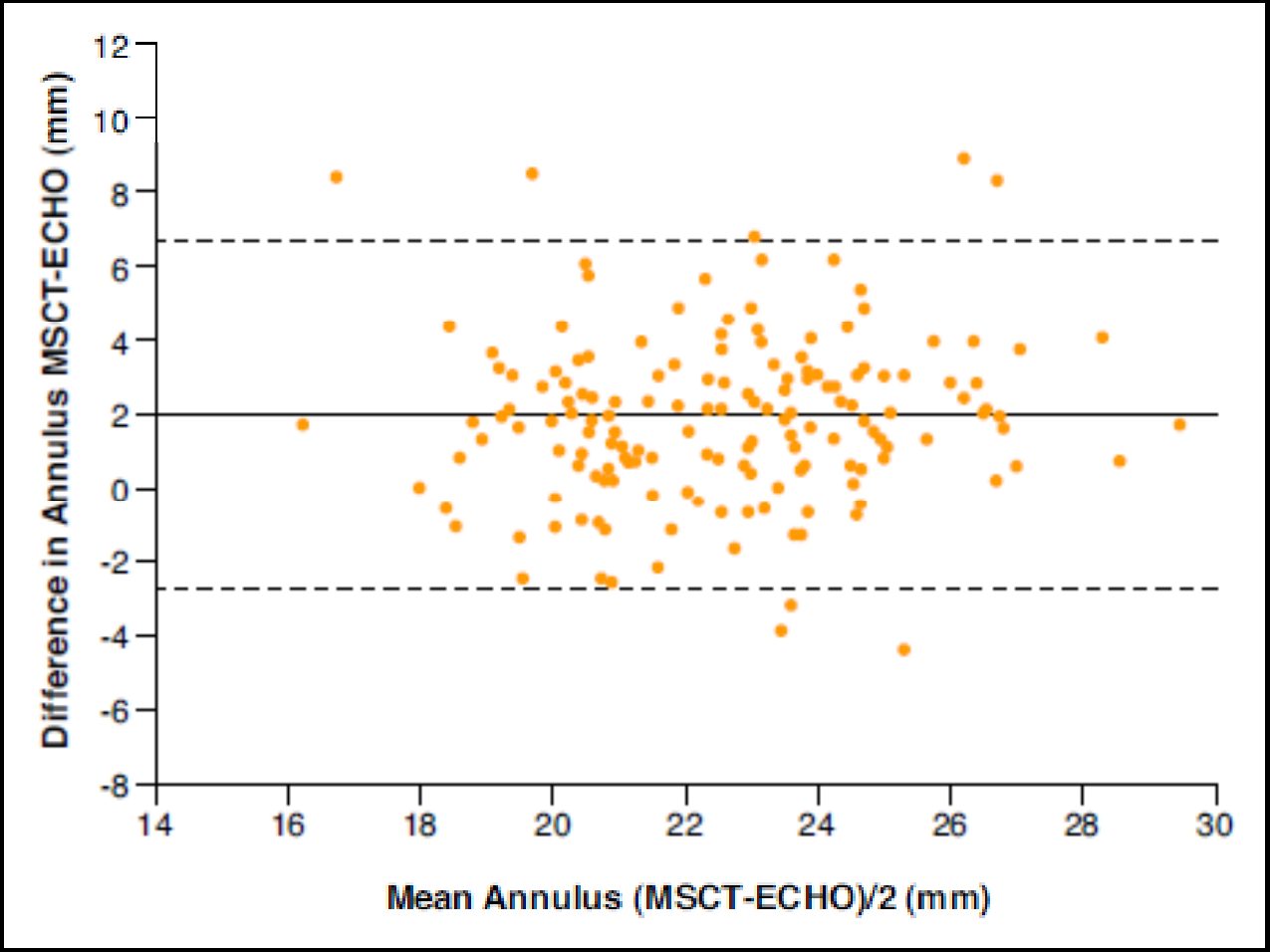
Accuracy of MDCT vs. Echo for Aortic Annulus Diameter

Tops, Wood, Schuijf, JG Webb, JJ Bax JACC Img 2008;1:321-30



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Aortic Root / LVOT Structure Not Simple

- Aortic root more complex than simple “tube”
  - Can be oval in shape
  - Can remodel and change with aging and disease
  - Calcification

Aortic Root Remodeling in AS

Akhtar M, Tuzcu EM, Halliburton S, Schoenhagen P, et al.
Presented at Society of Cardiovascular CT Annual Meeting 2008

Parameter	Aortic Stenosis (n=25)	Controls (n=25)	p-value
Aortic valve annulus to right coronary artery ostium (mm)	13.6 ±2.8	15.2 ± 2.5	0.04
Aortic valve annulus to left coronary artery ostium (mm)	13.4 ±3.2	15.6 ± 2.7	0.01
Aortic valve annulus to sinotubular junction (mm)	16.7 ±2.0	21.0 ± 2.3	<0.01
Aortic valve annulus diameter (mm)	27.2 ±3.5	27.2 ± 4.0	0.99
Sinuses of Valsalva diameter (mm)	34.7 ±4.7	36.7 ± 5.3	0.17
Sinotubular junction diameter (mm)	27.1 ±3.8	28.2 ± 4.7	0.40
Left ventricular outflow tract (mm)	24.6 ±3.6	25.1 ± 3.0	0.65

- 25 AS pts compared to 25 age & sex matched controls
- MDCT and measured valve annulus to coronaries and ST junction
- Shorter length in AS patients
- Implications for perc AVR (possibly increased risk of coronary complication by valve during implant)

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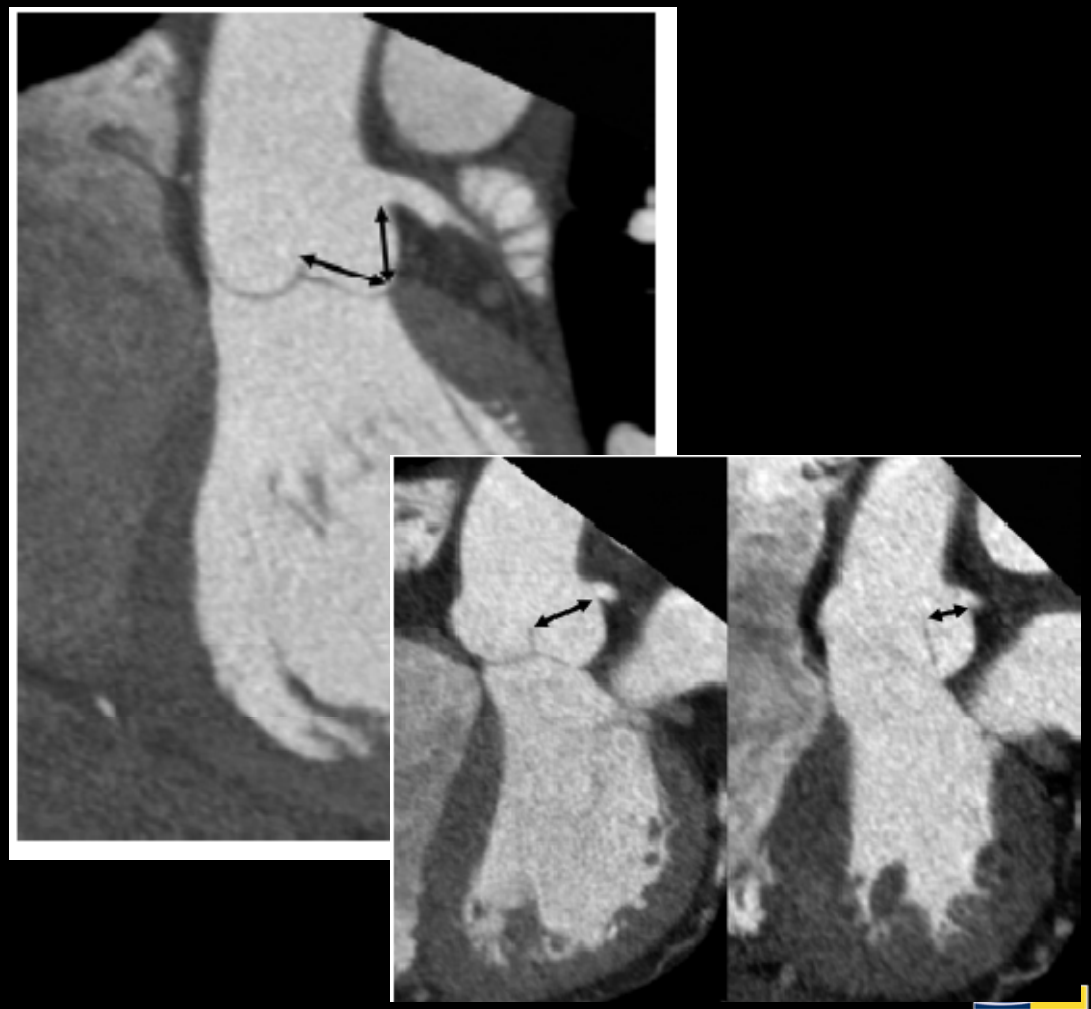
Aortic Root Measurements

Sinus of Valsalva; Left Coronary Ostium; Leaflet

Tops, Wood, Schuijf, JG Webb, JJ Bax JACC Img 2008;1:321-30



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Heads Up: Potential Problems

Tops, Wood, Schuijf, JG Webb, JJ Bax JACC Img 2008;1:321-30

(A & B) Ovoid annulus: long axis diameter of 27.3 mm but short axis diameter of 20.3 mm
(C) Short distance to left coronary ostium (11.6 mm) relative to length of left coronary leaflet (13.4 mm)

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Aortic Calcification

- Mild (A)
- Moderate (B)
- Heavy = may be associated with commissural fusion (C)
- Massive = extending beyond annulus plane (D)

Table 8. Classification of Calcification Types

DLZ-CS Grade	Comment	AgS (AU)
1	Mild calcification	≤1,000
2	Moderate calcification	1,001–3,000
3	Heavy calcification (mostly with commissural fusion)	3,001–5,000
4	Massive calcification (with calcification clumps outreaching the annulus level)	>5,000

AgS = Agatston score; DLZ-CS = device landing zone calcification score.

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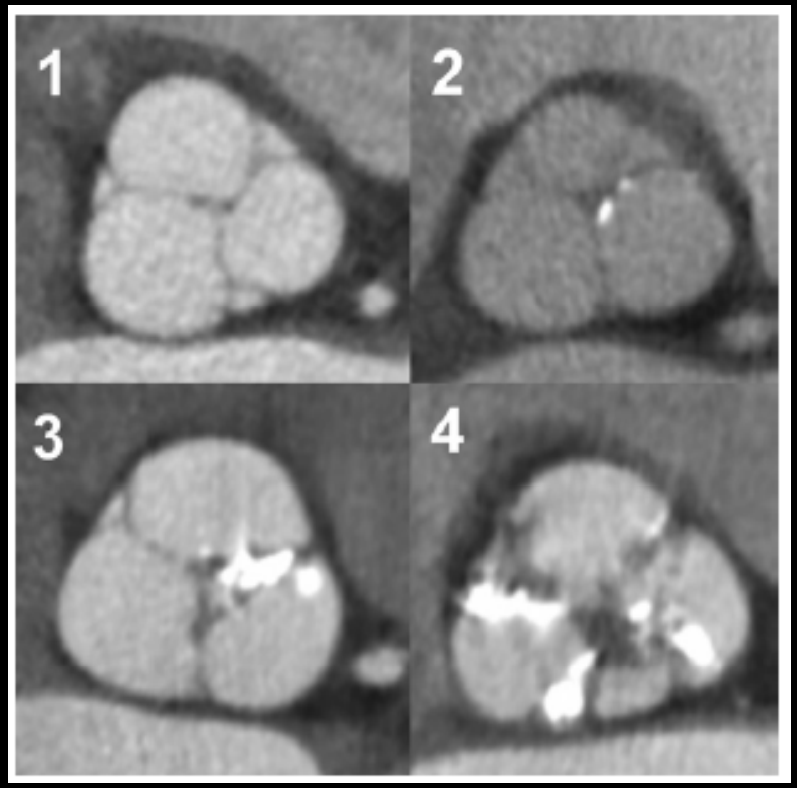
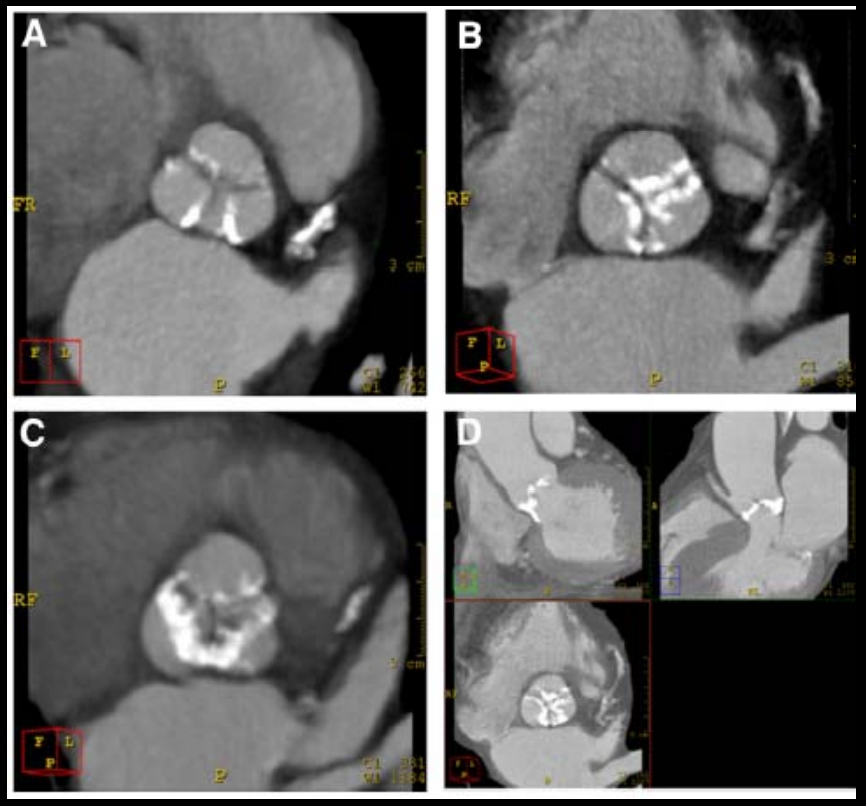
Aortic Valve Calcification

No standard classification

Tops, Wood, Schuijf, JG Webb, JJ Bax JACC Img 2008;1:321-30





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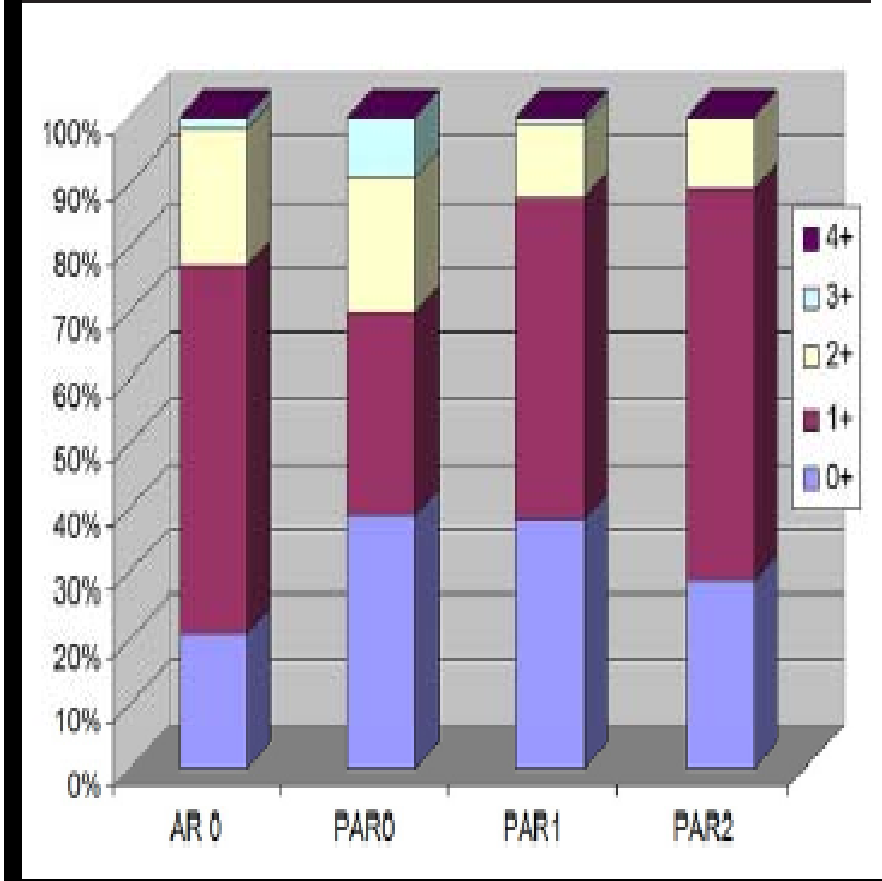
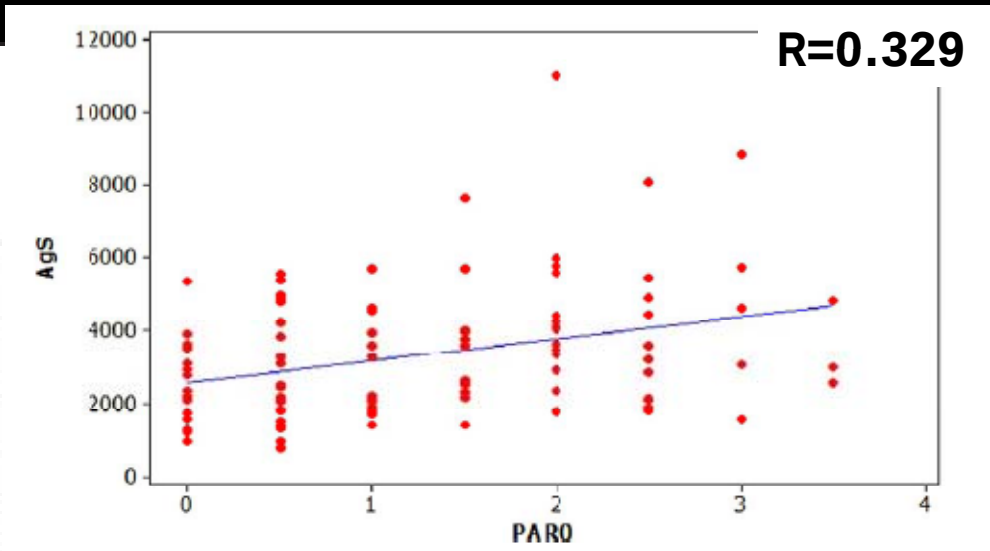
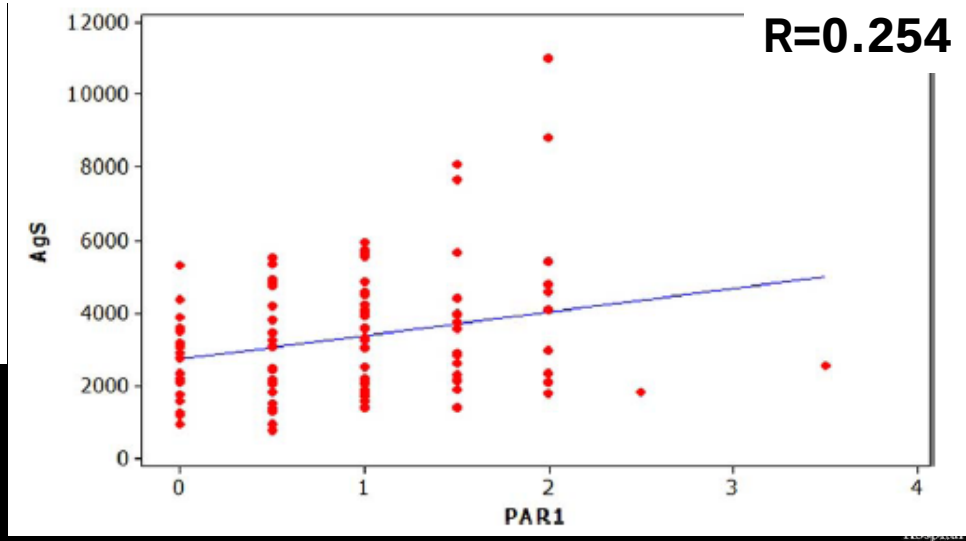
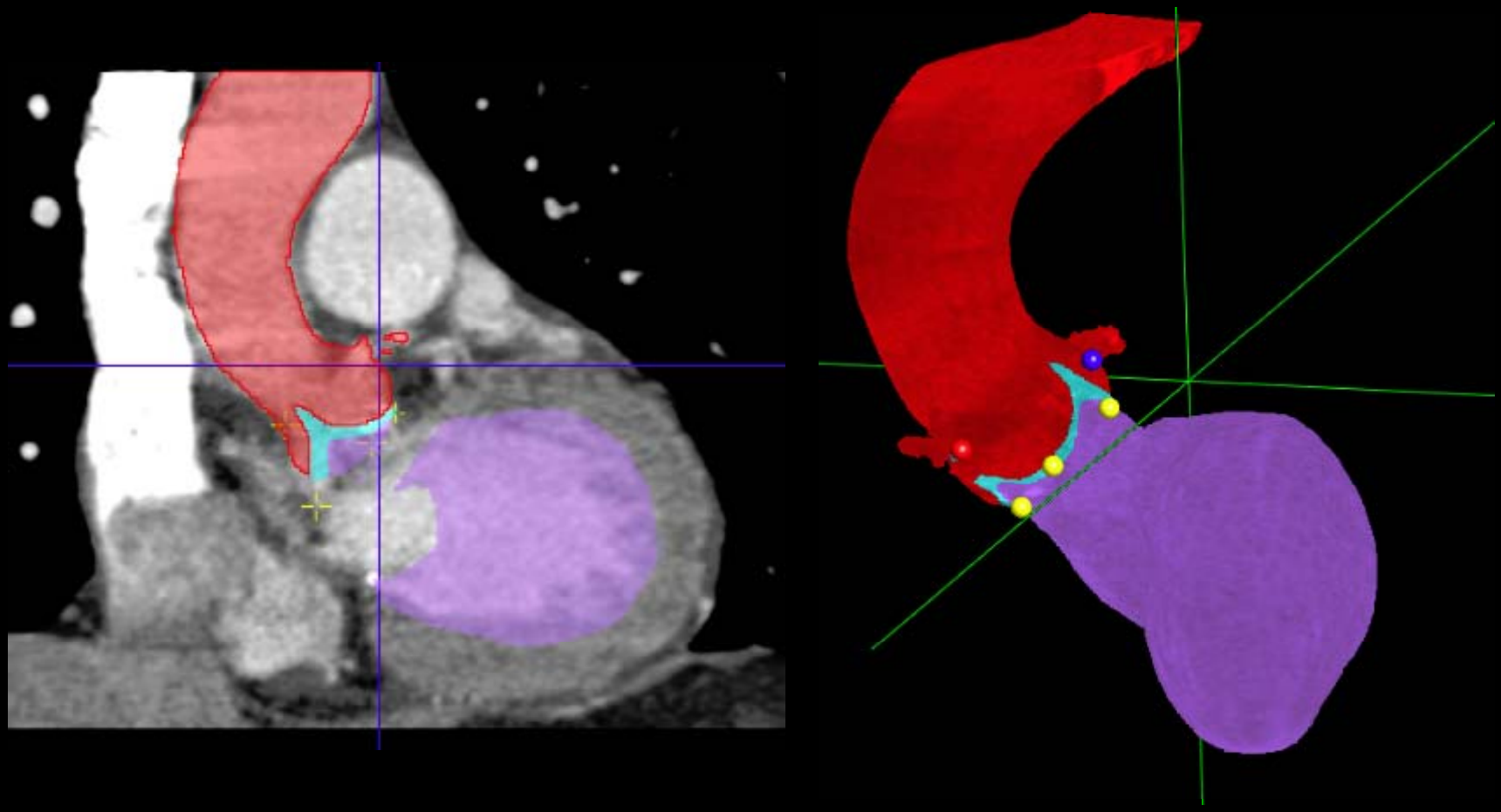
Weak correlation between calcification and aortic regurg







TAVI Guided by CT Angio



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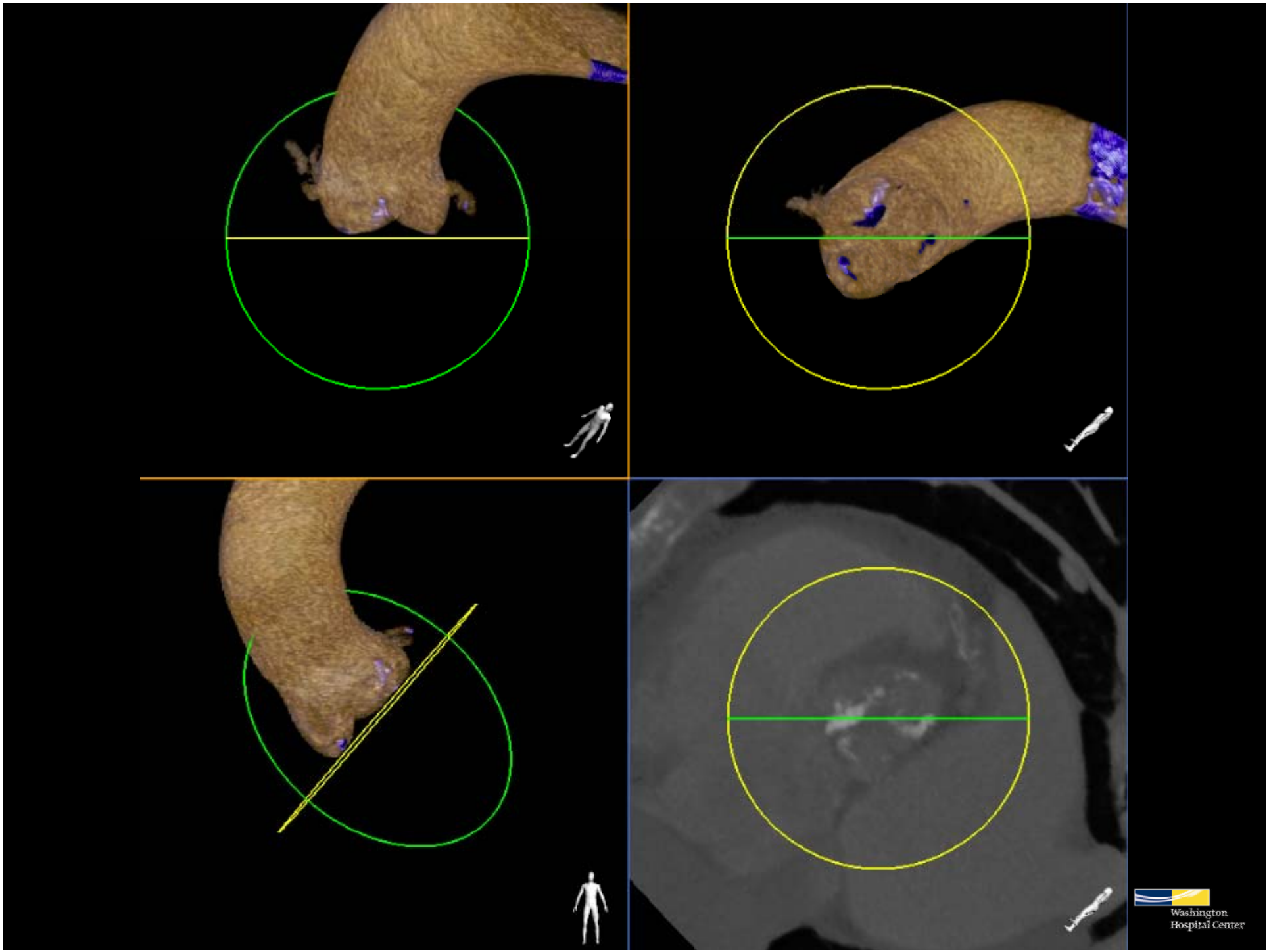
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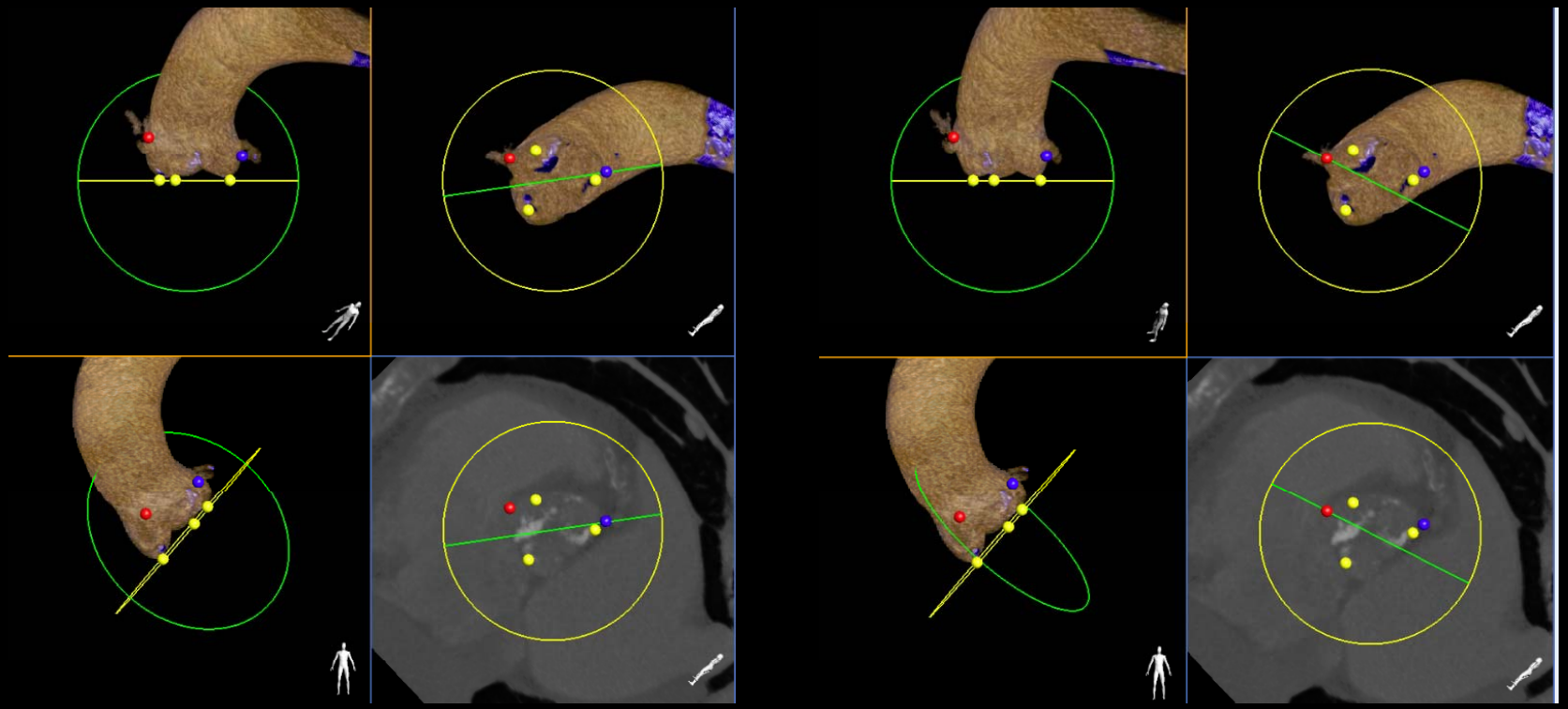

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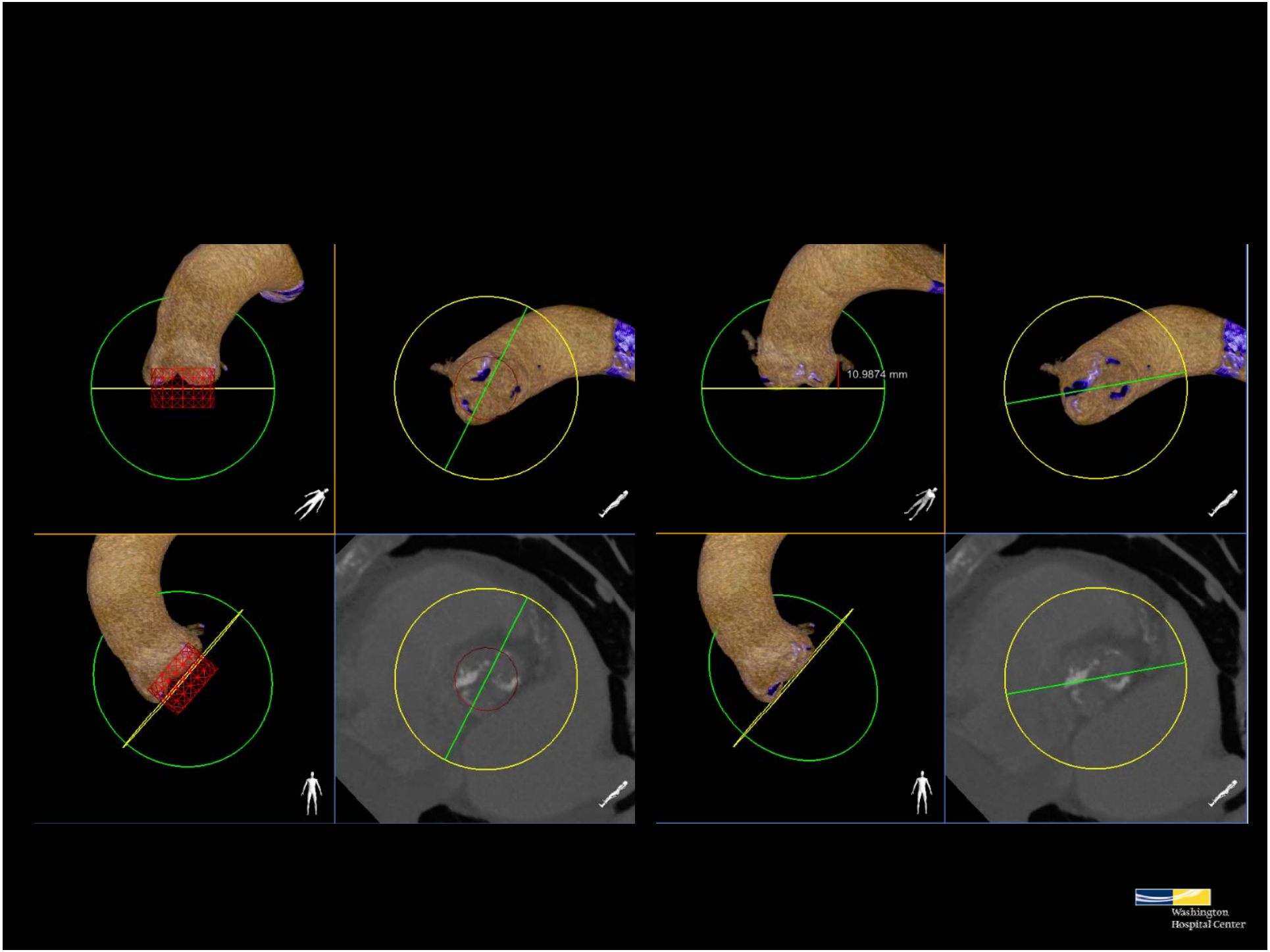
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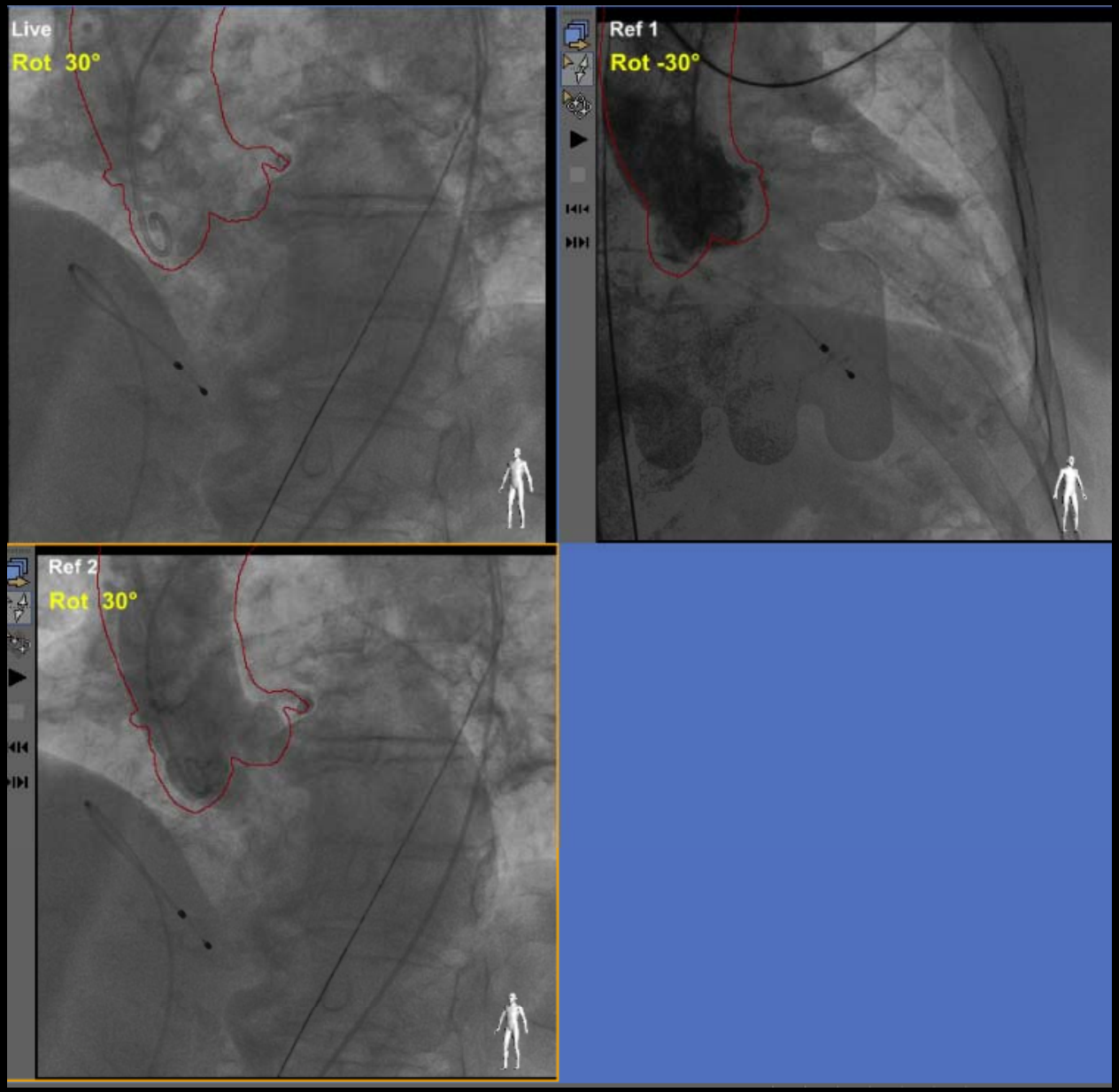

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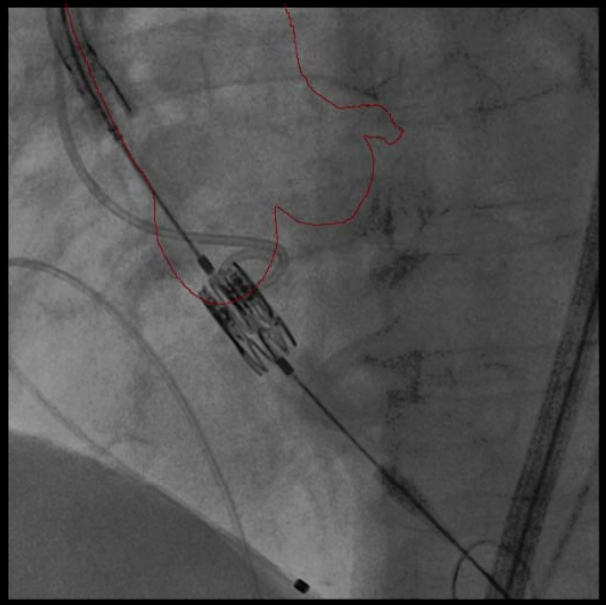

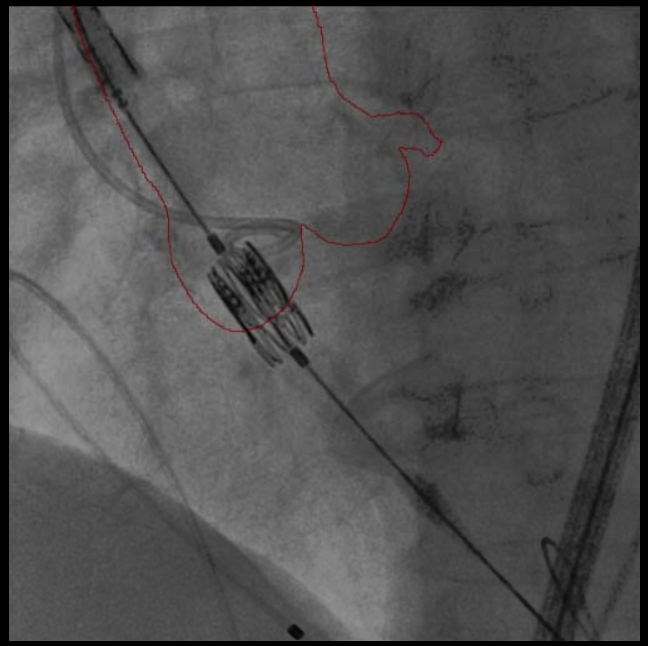

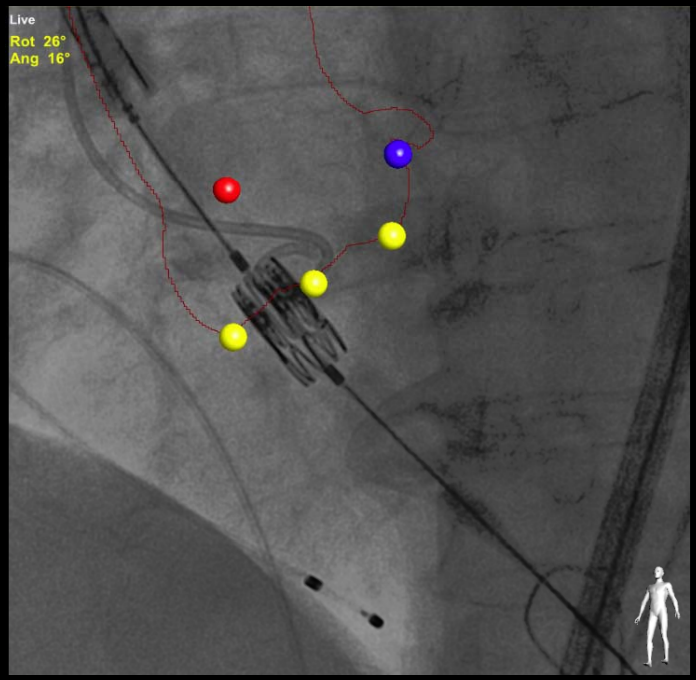

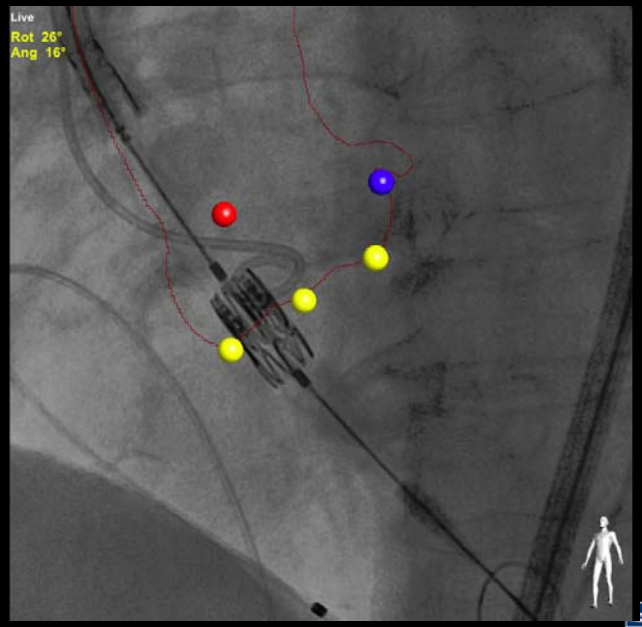

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Conclusions

- CTA has a potential role in the pre-procedure evaluation and planning of TAVI
  - Peripheral vascular access
  - Aortic root morphometry
  - Device sizing
  - Prediction of problems / complications
  - Patient selection
    - Also: used by surgeons if patients are post-CABG