FACULDADE DE MEDICINA LISBOA

HOSPITAL DE SANTA MARIA

Functional mitral regurgitation revisited

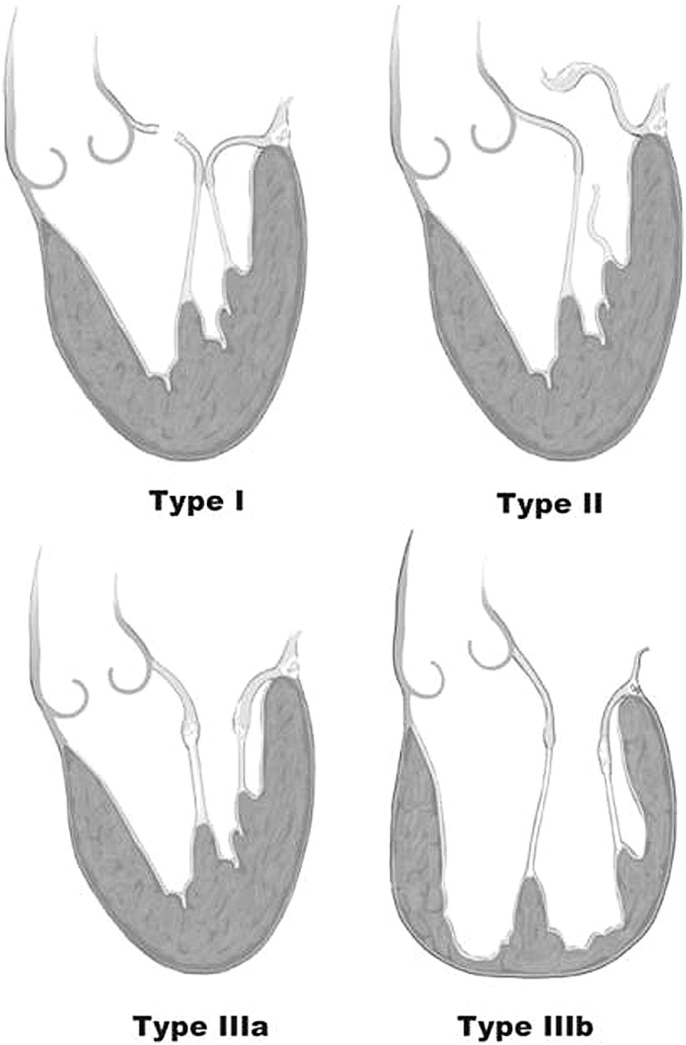
CMR and CT: added value?

Ana G. Almeida

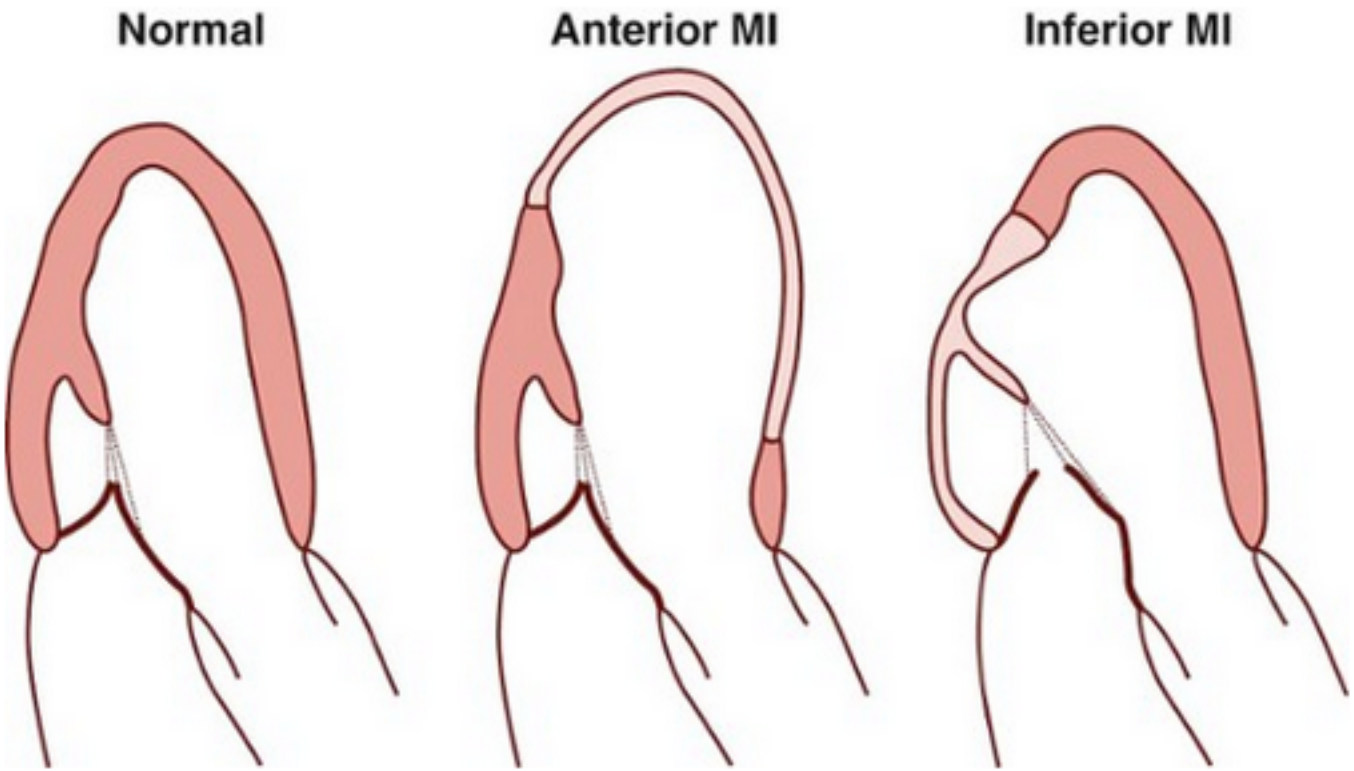
Functional mitral regurgitation

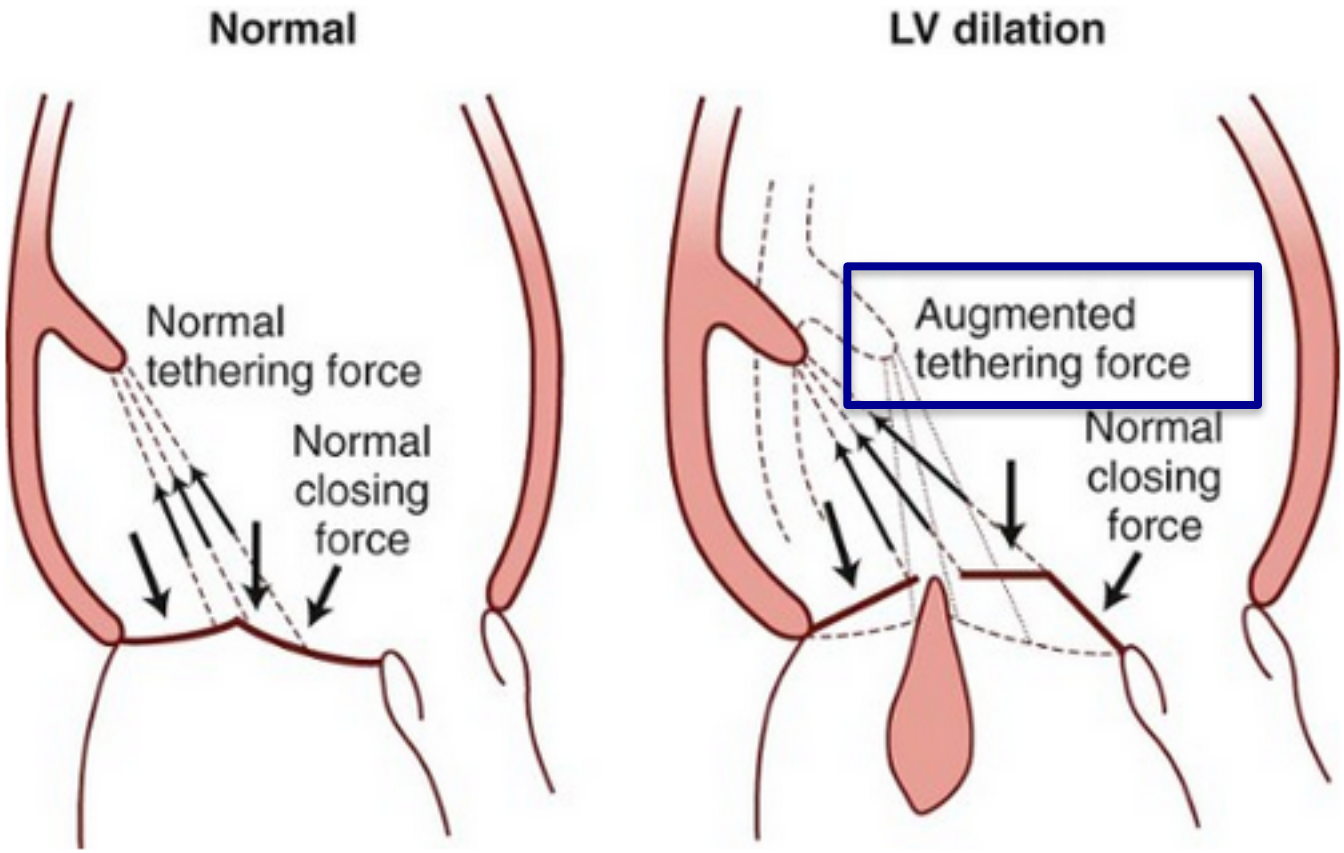
Ischemic
- Inferior MI
- Papillary muscle rupture – LCX/RCA
- Anterior MI and LV remodeling

Non-ischemic
- Dilated CMP
- HCM



Ischemic mitral regurgitation

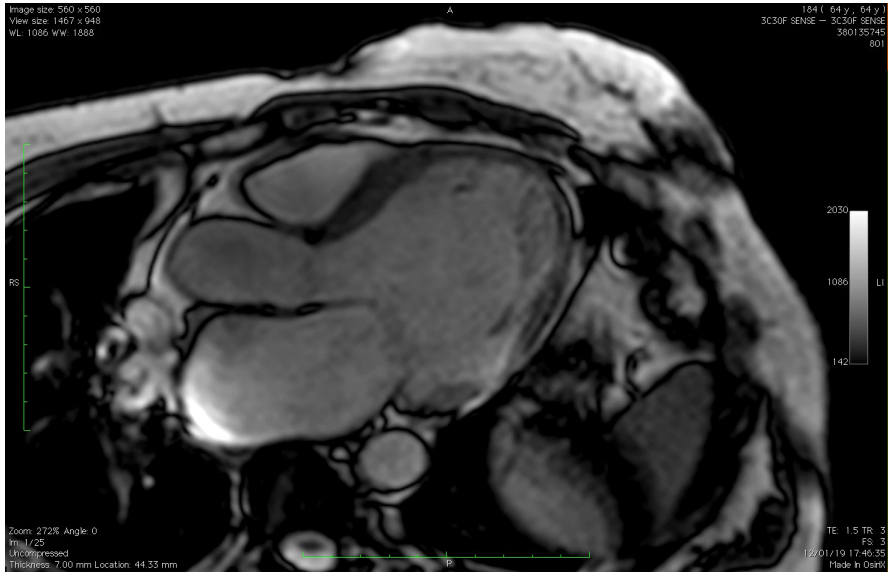



Normal
Normal tethering force
Normal closing force
LV dilation
Augmented tethering force
Normal closing force

Asymmetric versus Symmetric Tethering

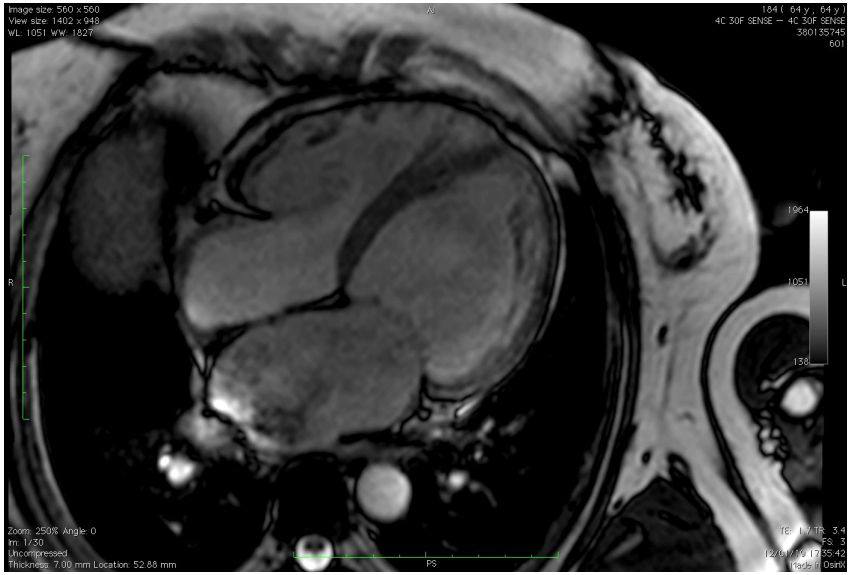
	ASYMMETRIC	SYMMETRIC
Etiology	Inferior myocardial infarction (MI)	Large anterior or multiple MIs Nonischemic cardiomyopathy
Tethering	Posterior leaflet	Both leaflets
Tenting	Increased	Markedly increased
Annulus	Mild to no dilation	Dilated, flattened
Left ventricular remodeling	Inferior wall alone	Global dilation with increased sphericity
Mitral regurgitation jet direction	Posterior	Usually central

Posterior MI



Localized remodelling
PM displacement
Mild annulus dilatation
Asymmetric tethering
Moderate tenting

Ischemic cardiomyopathy



Global remodelling
Annulus dilatation
Symmetric tethering
Severe tenting

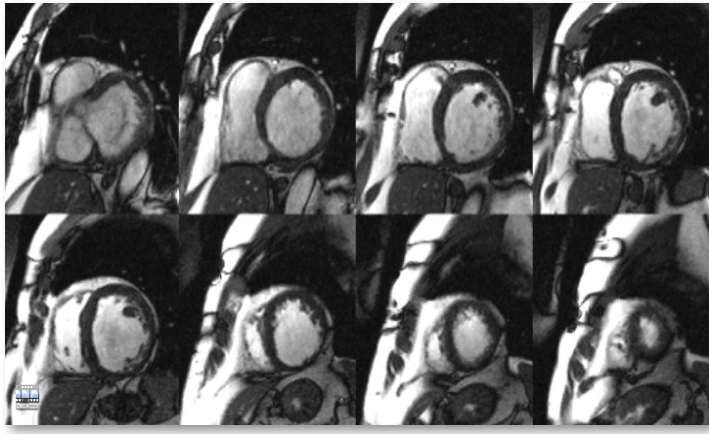
- **CMR and CT**
- Added value to echo assessment?

- ***Mitral regurgitation severity***

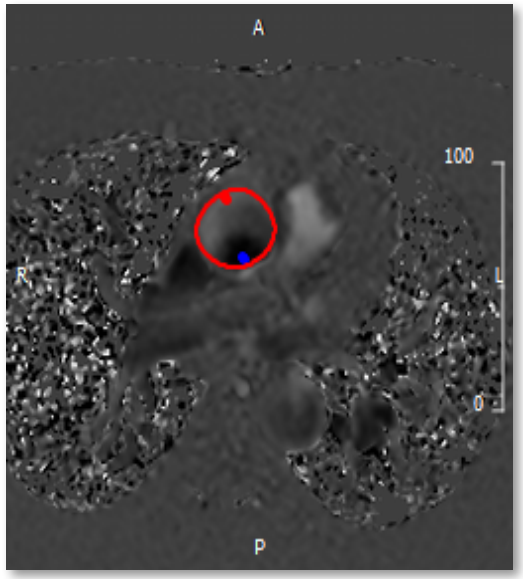
CMR: Qualitative assessment

Quantitative assessment

- LV stroke volume-RV stroke volume = Rvol and RF
- LV stroke volume-aortic forward flow = Rvol/RF



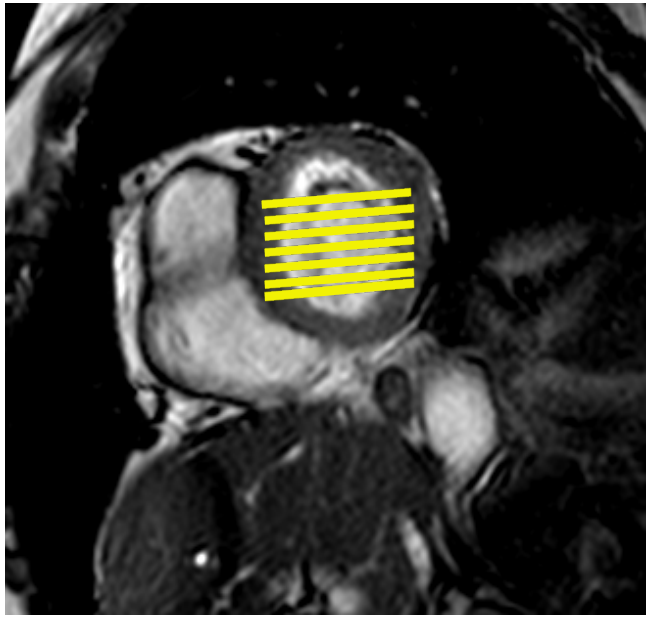
- Accurate and reproducible assessment, independent of jet number and eccentricity
- Reliable when there are 2 associated lesions

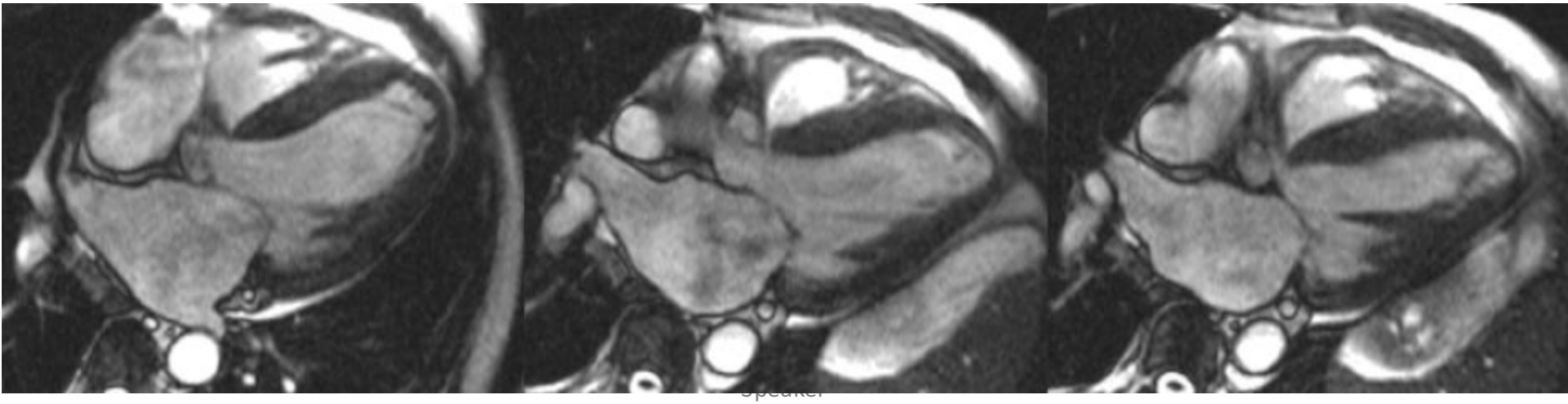


- ***Anatomic characterization, etiology and prediction of fMR***

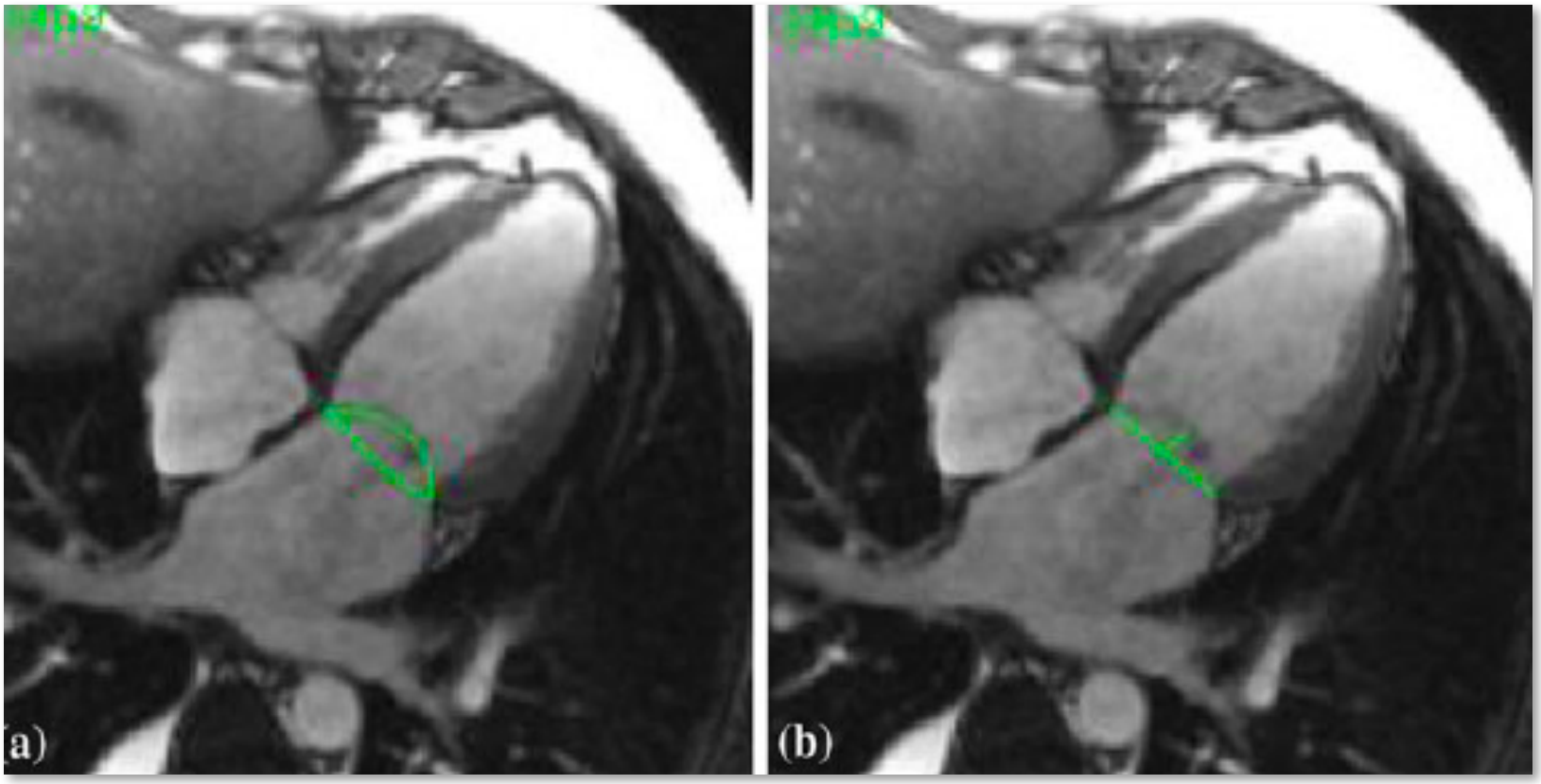
CMR: Mitral valve anatomy

5 mm stack covering all MV scallops





CMR and CT

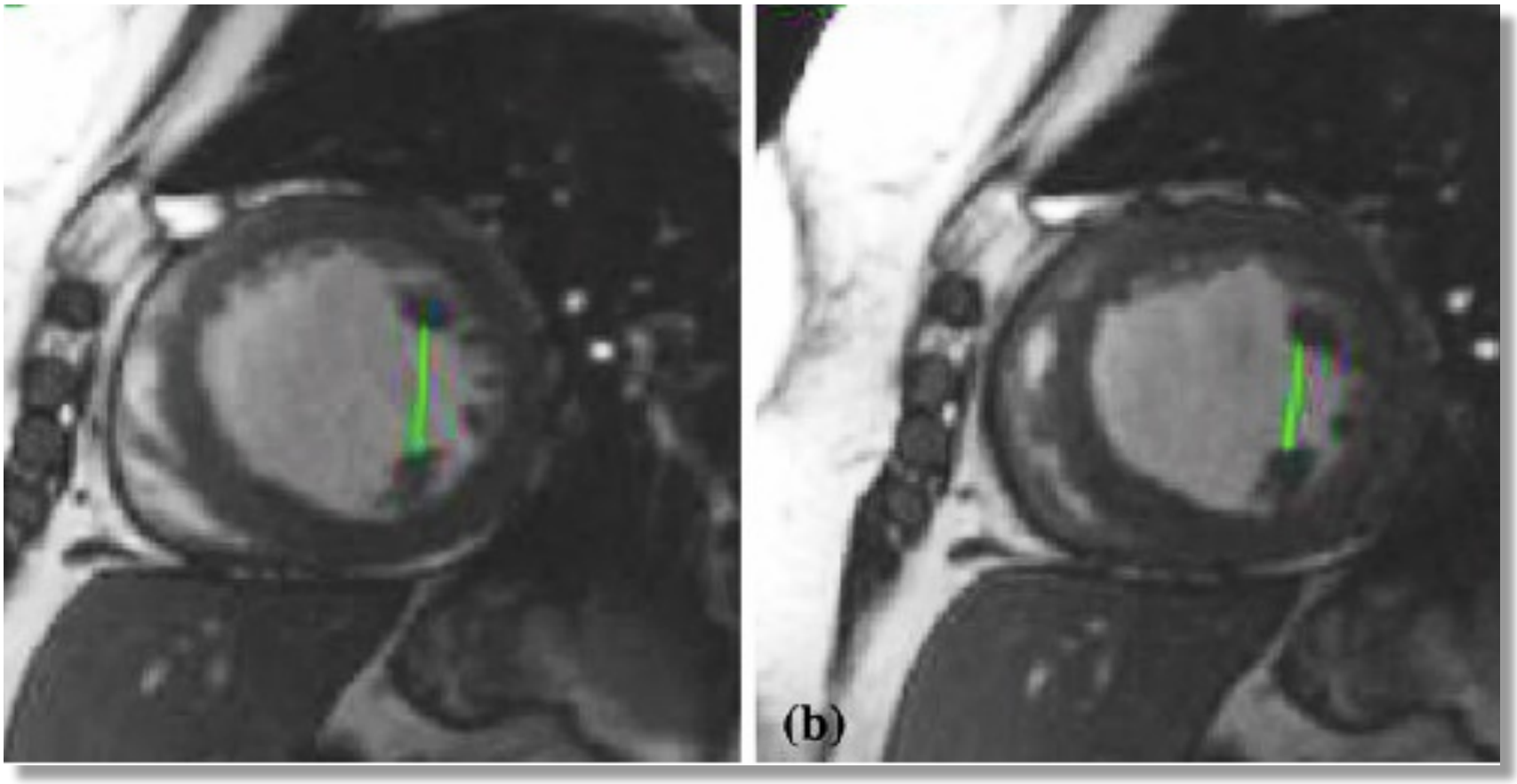


- Tenting area, coaptation depth, annulus dimension, leaflet length ……..

CMR better than CT (temporal resolution)

ED inter PM distance

ES inter PM distance



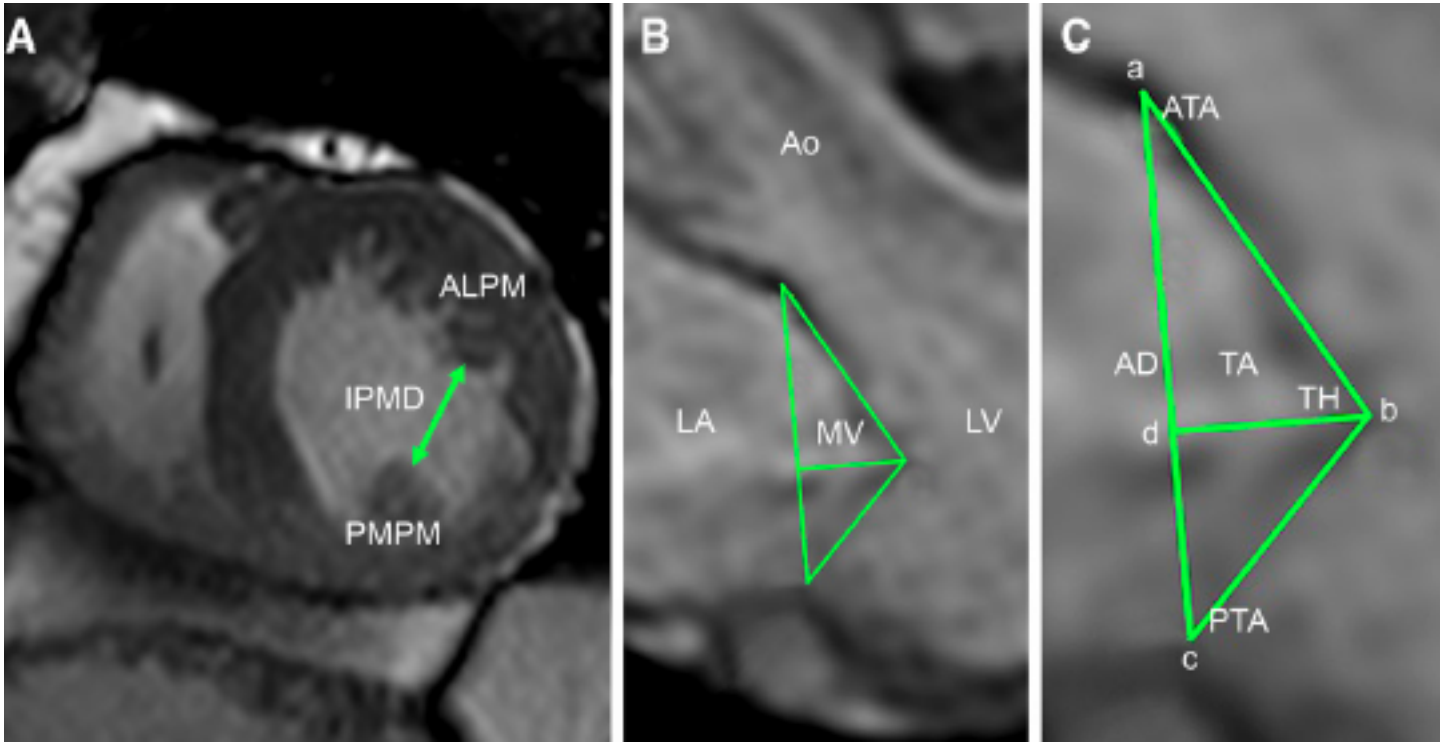
Fernandez-Golfin et al. Int J Cvim 2011

Cardiac magnetic resonance determinants of functional mitral regurgitation in ischemic and non ischemic left ventricular dysfunction

	MR+ (mean ± SD)	MR− (mean ± SD)	*P*
ILVD n = 45			
Tenting area (cm^2)	2.12 ± 0.77	1.16 ± 0.69	*0.001*
Coaptation depth (cm)	1.04 ± 0.32	0.62 ± 0.24	*<0.001*
Mitral annular diameter (cm)	3.57 ± 0.68	3.10 ± 0.48	*0.007*
Anterior MV leaflet length (cm)	2.42 ± 0.32	1.99 ± 0.43	*0.009*
Posterior MV leaflet length (cm)	1.65 ± 0.36	1.32 ± 0.29	*0.007*
ED inter PM distance (cm)	3.44 ± 0.90	2.72 ± 0.59	*0.006*
ES inter PM distance (cm)	2.77 ± 0.81	2.02 ± 0.67	*0.007*
MV ED inter-commissural diameter (cm)	3.84 ± 0.56	3.60 ± 0.51	0.243
MV ES inter-commissural diameter (cm)	2.75 ± 0.47	2.29 ± 0.45	*0.017*
NILVD n = 35			
Tenting area (cm^2)	1.75 ± 0.80	1.35 ± 0.58	0.105
Coaptation depth (cm)	0.91 ± 0.28	0.73 ± 0.24	0.062
Mitral annular diameter (cm)	3.08 ± 0.72	3.20 ± 0.47	0.602
Anterior MV leaflet length (cm)	2.15 ± 0.42	2.07 ± 0.31	0.541
Posterior MV leaflet length (cm)	1.71 ± 0.47	1.49 ± 0.37	0.147
ED inter PM distance (cm)	3.04 ± 0.47	2.51 ± 0.51	*0.008*
ES inter PM distance (cm)	2.19 ± 0.48	1.60 ± 0.41	*0.001*
MV ED inter-commissural diameter (cm)	3.69 ± 0.28	3.80 ± 0.41	0.351
MV ES inter-commissural diameter (cm)	2.59 ± 0.35	2.41 ± 0.43	0.269

Fernandez-Golfin et al. Int J Cvim 2011

Chronic ischemic mitral regurgitation and papillary muscle infarction detected by late gadolinium-enhanced cardiac magnetic resonance imaging in patients with ST-segment elevation myocardial infarction



380 pts with MI, 20% with partial PM infarction

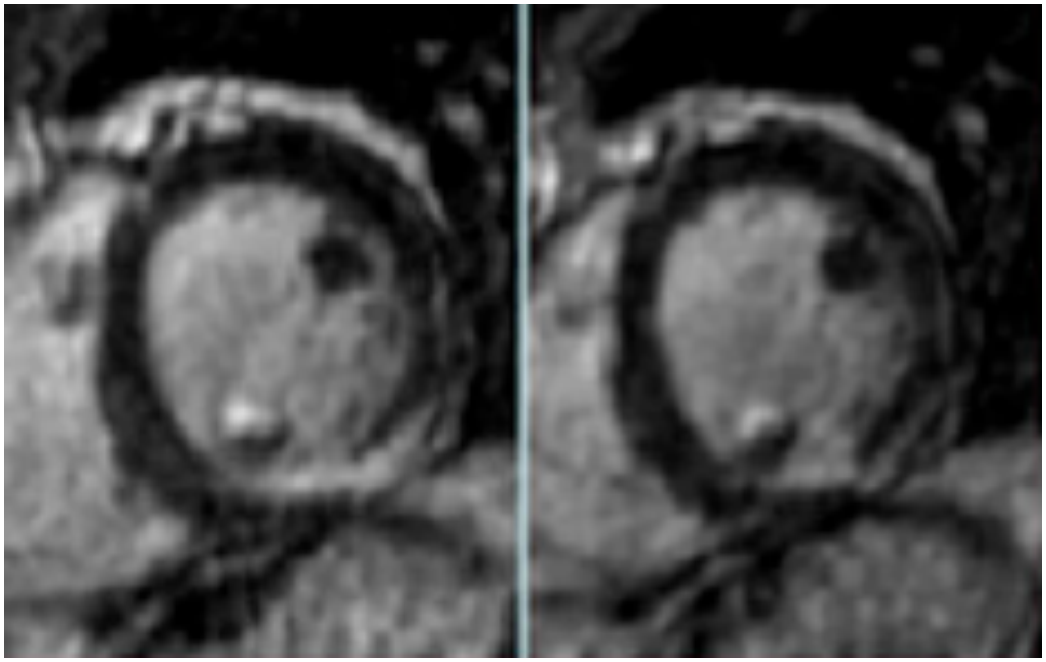
Bouam et al. Clin Res Cardiol 2016

Predictors of Functional Mitral Regurgitation

Variable	Univariate analysis		Multivariate analysis	
	OR (95 % CI)	*P* value	OR (95 % CI)	*P* value
Age, years	1.07 (1.04–1.10)	<0.001	1.08 (1.04–1.11)	<0.001
Female	1.40 (0.76–2.57)	0.285	–	
Maximum CK level, U/L	1.00 (1.00–1.00)	0.001	–	
Preintervention TIMI flow grade <3	3.03 (1.36–6.79)	0.007	–	
Infarct size, % LV hyperenhancement	1.07 (1.03–1.11)	<0.001	1.09 (1.03–1.16)	0.003
Inferior MI	1.99 (0.97–4.11)	0.062	–	
PMI	3.02 (1.67–5.46)	<0.001	–	
LA volume, ml	1.02 (1.01–1.04)	0.003	–	
LV end-systolic diameter, mm	1.04 (1.00–1.09)	0.058	–	
Systolic sphericity index, %	1.06 (1.01–1.10)	0.012	–	
Interpapillary muscle distance, mm	2.79 (1.54–5.04)	0.001	3.32 (1.31–8.42)	0.011
LVEF, %	0.97 (0.94–1.00)	0.040	–	
Wall motion score index	3.60 (1.38–9.41)	0.009	–	
Tethering height, mm	19.03 (4.57–79.22)	<0.001	19.30 (3.28–113.61)	0.001
Tethering area, mm^2	3.04 (1.56–5.93)	0.001	–	
Posterior tethering angle, °	1.05 (1.02–1.08)	0.003	–	
Anterior tethering angle, °	1.07 (1.02–1.12)	0.004	–	

Bouam et al. Clin Res Cardiol 2016

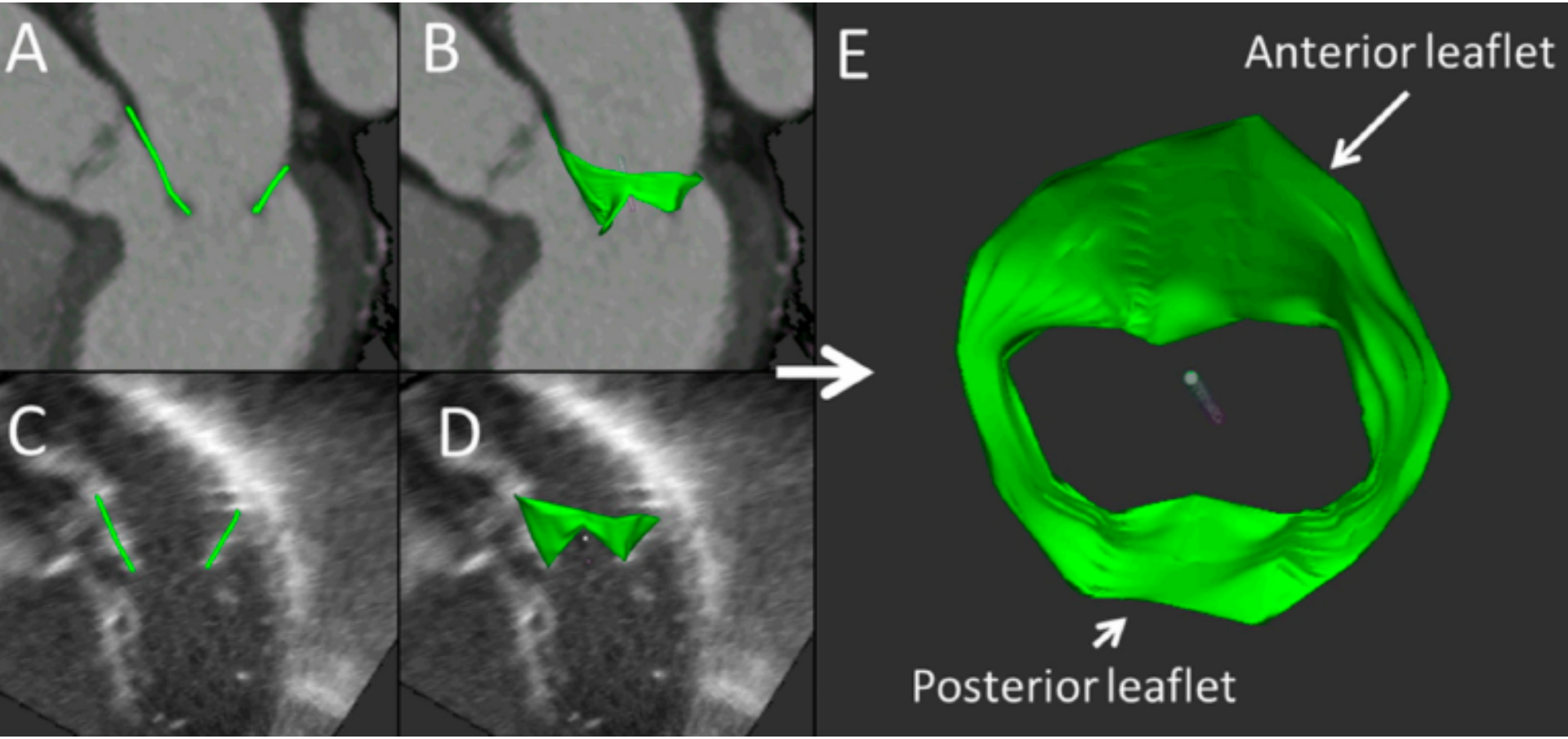
Mitral Apparatus Assessment by Delayed Enhancement CMR – Relative Impact of Infarct Distribution on Mitral Regurgitation



- 153 first MI, PMI 30% - PMI was not independently associated to fMR
- In multivariable analysis, **lateral wall infarct size** was independently associated with ≥moderate fMR

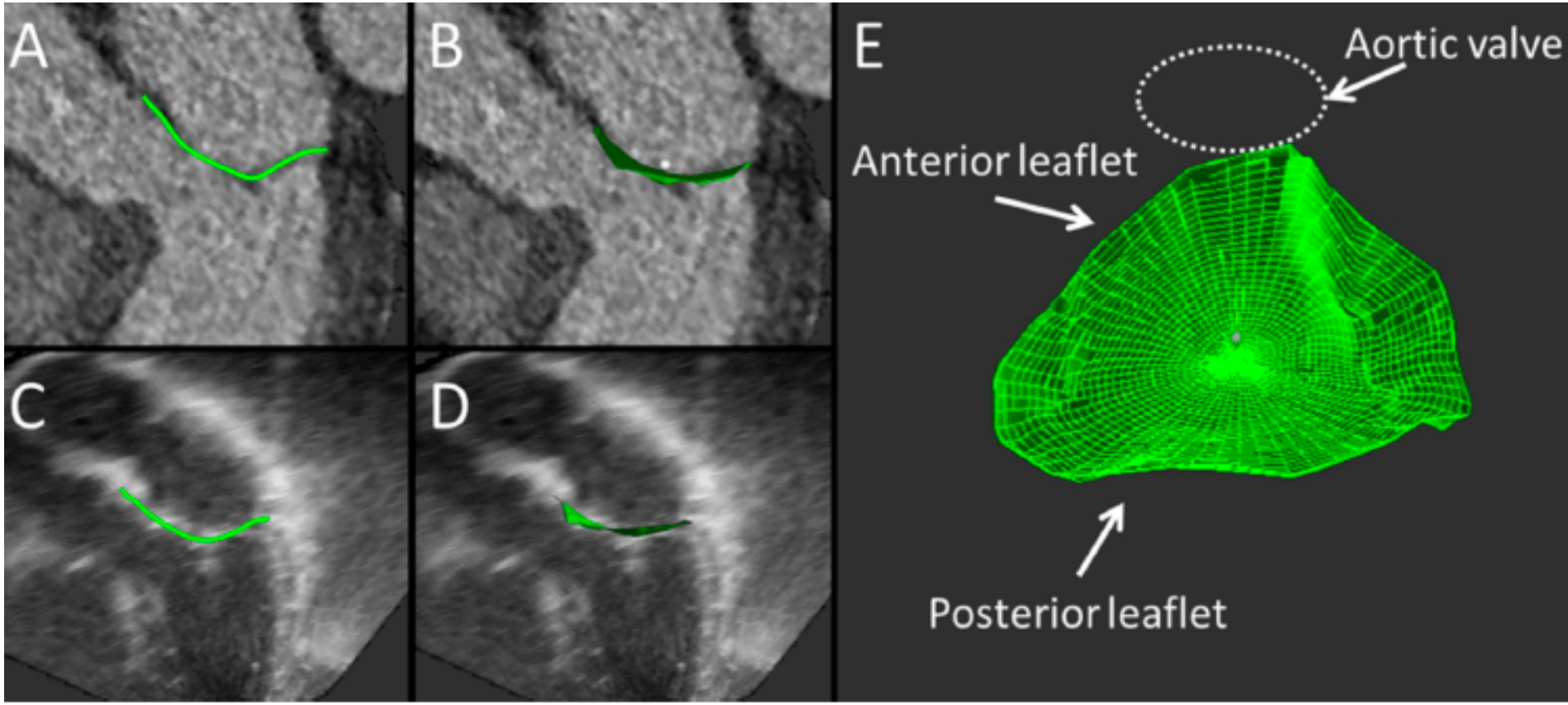
Chinitz et al. JACC Cardiov Im 2013

Assessment of Mitral Valve Adaptation with Gated Cardiac Computed Tomography: Validation with Three-Dimensional Echocardiography and Mechanistic Insight to Functional Mitral Regurgitation



Total mitral leaflet area

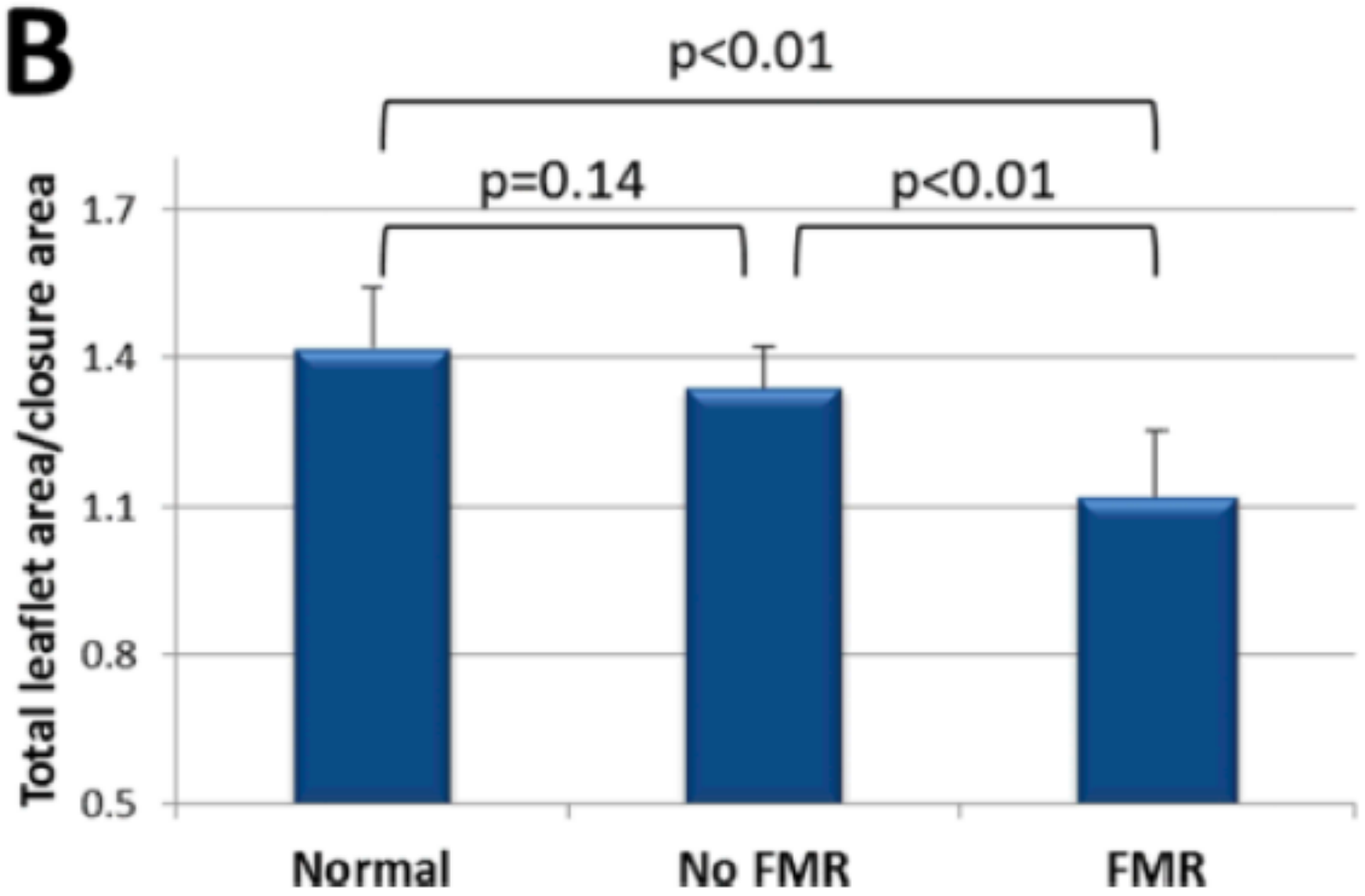
Beaudoin et al. Circ Cardiovasc Imaging . 2013



Mitral closure area

Beaudoin et al. Circ Cardiovasc Imaging . 2013

Nl versus DCM (without MR versus with fMR)



Mitral valve enlargement for adapting to prevent MR in patients with abnormal LV function

Beaudoin et al. Circ Cardiovasc Imaging . 2013

Mitral leaflets size - CT reproducibility

Inter- and intra-observer reproducibility of CT mitral valve metrics

	Average difference* (cm^2)	Relative difference (%)	ICC	p value
Interobserver				
Total leaflet area	0.6	4.4	0.974	<0.01
Closure area	0.9	7.6	0.922	<0.01
Annulus area	0.7	6.3	0.944	<0.01
Intraobserver				
Total leaflet area	0.6	4.2	0.979	<0.01
Closure area	0.5	5.1	0.977	<0.01
Annulus area	0.5	5.3	0.976	<0.01

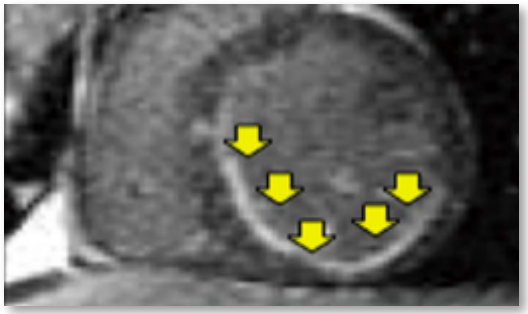
ICC: Intraclass Correlation Coefficient.

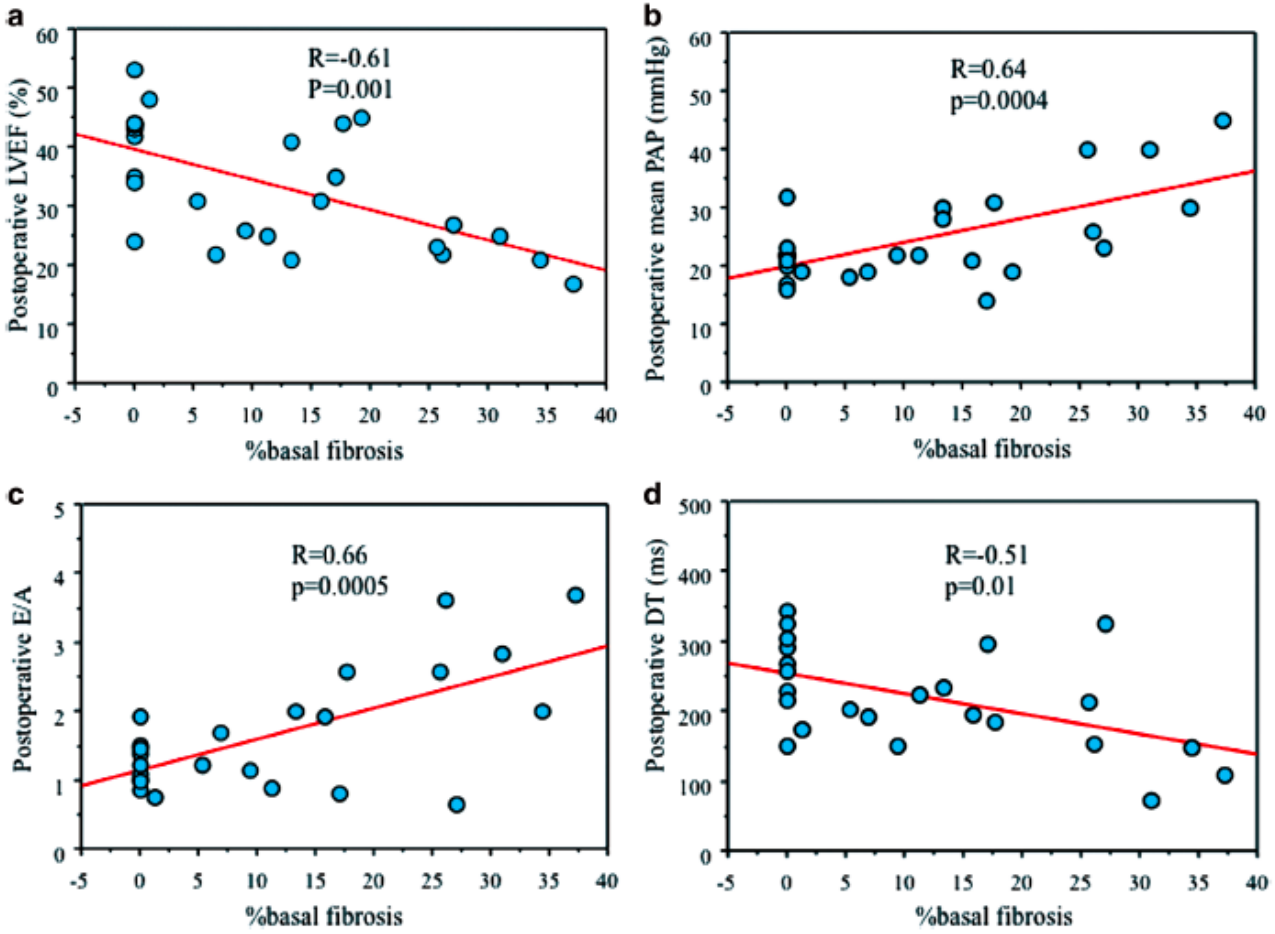
- ***Prognosis***

Left Ventricular Basal Myocardial Scarring Detected by Delayed Enhancement Magnetic Resonance Imaging Predicts Outcomes After Surgical Therapies for Patients With Ischemic Mitral Regurgitation and Left Ventricular Dysfunction

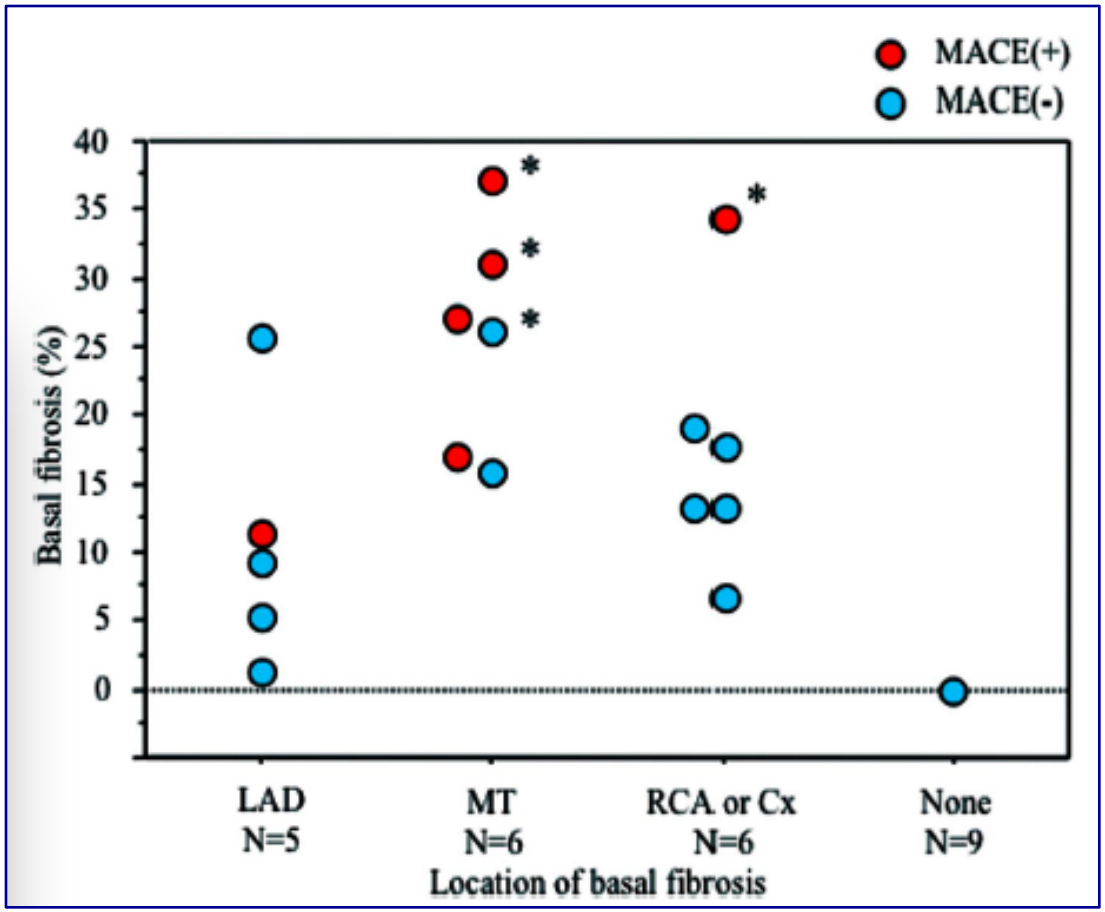
Pts with IMR and annuloplasty

Extent of fibrosis was related to postop LVEF





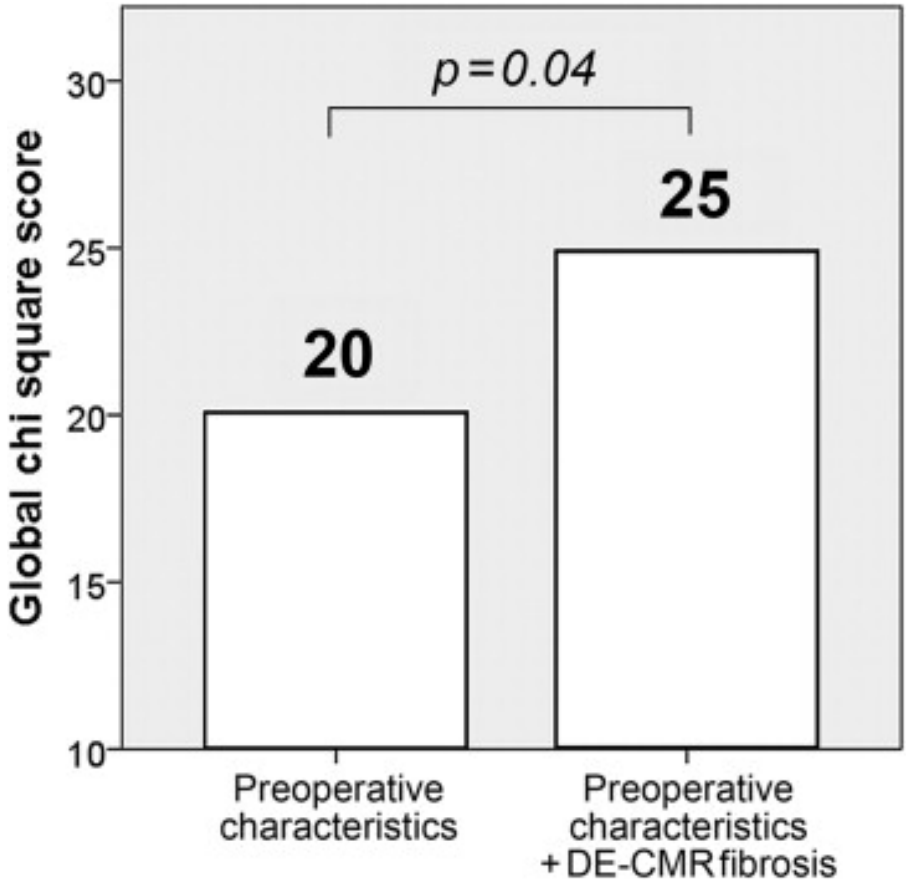
Takeda et al. Circ j 2011



- Basal segments with fibrosis - lack of improvement after annuloplasty (lack of reverse remodeling and geometric recovery)
- The basal portion of the LV is connected with **longitudinal subendocardial muscle fibers** sensitive to pathological conditions including ischemia and infarction as compared with the apical portion

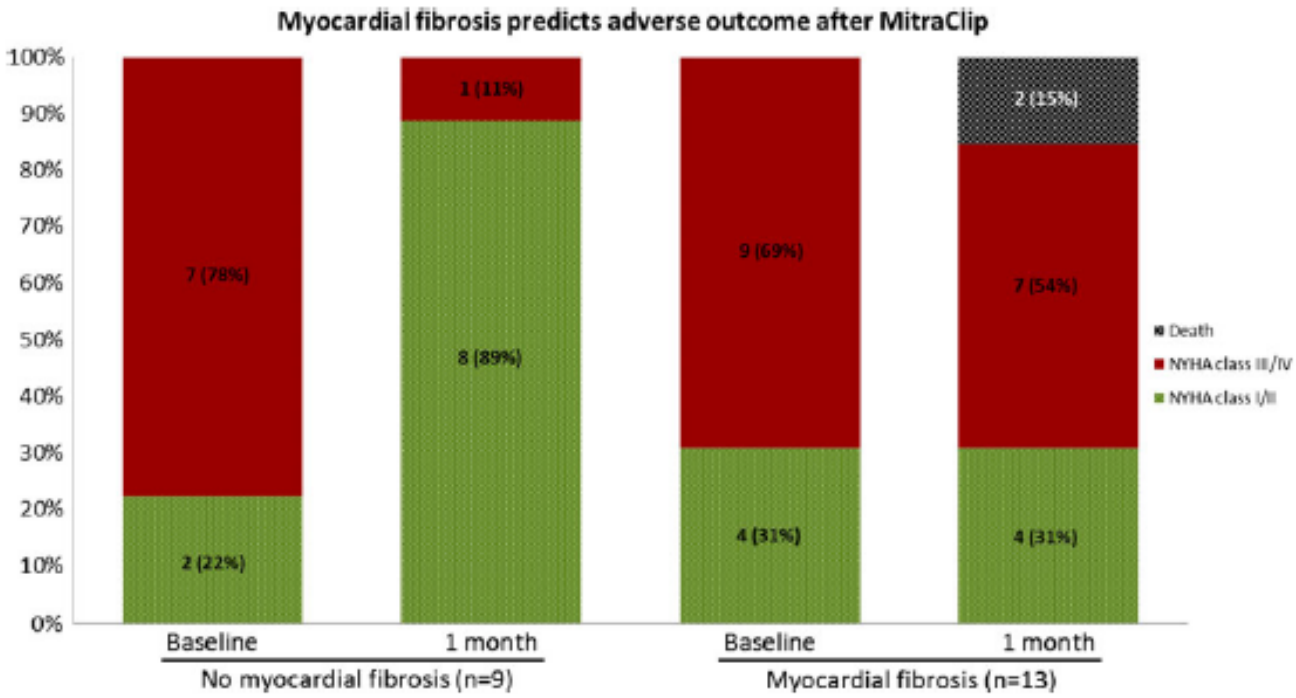
Takeda et al. Circ j 2011

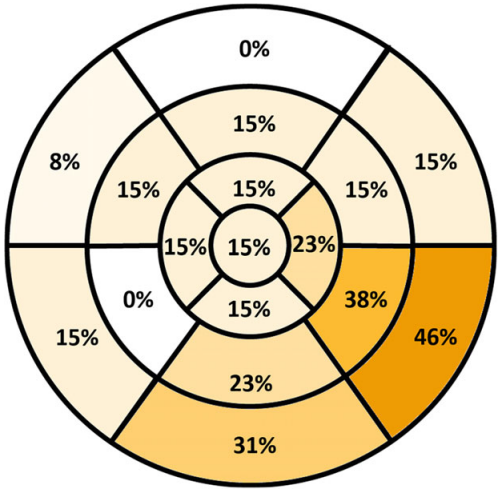
Prognostic Value of Delayed Enhancement Cardiac Magnetic Resonance Imaging in Mitral Valve Repair



Fibrosis by LGE CMR was an independent predictor of MACE after surgical repair among clinical variables, risk factors and pre-operative characteristics of MV

Fibrosis and prediction of MACE after Mitraclip





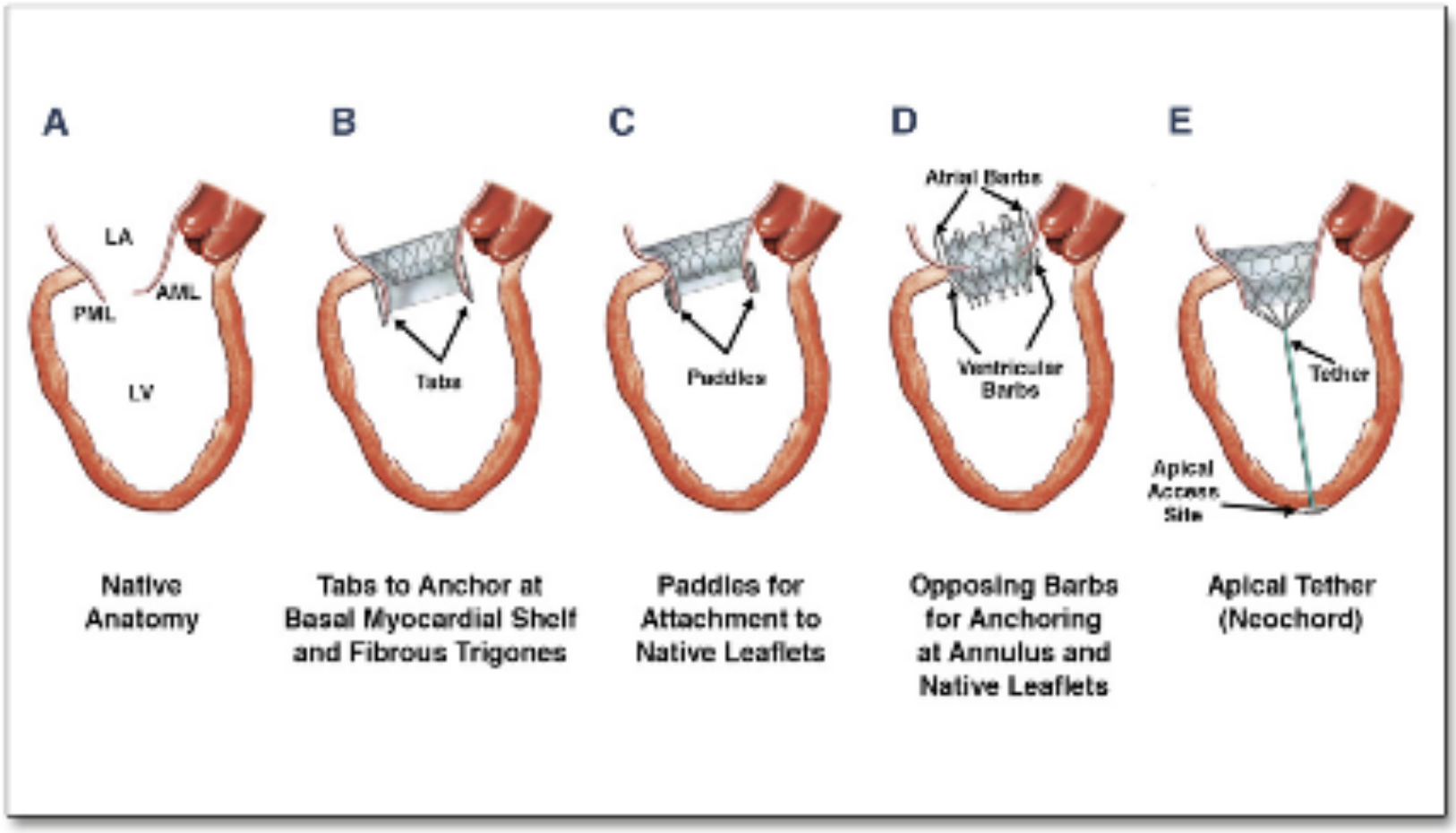
33 pts Mitraclip for functional mitral regurgitation; fibrosis of inferolateral segments were the most prevalent

Velu et al. Catheter Cardiovasc Interv. 2018;1–4.

- ***Assessment before intervention***

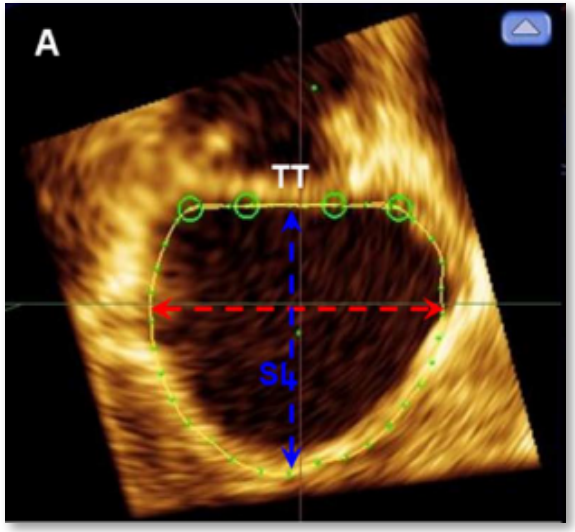
Transcatheter Mitral Valve Replacement

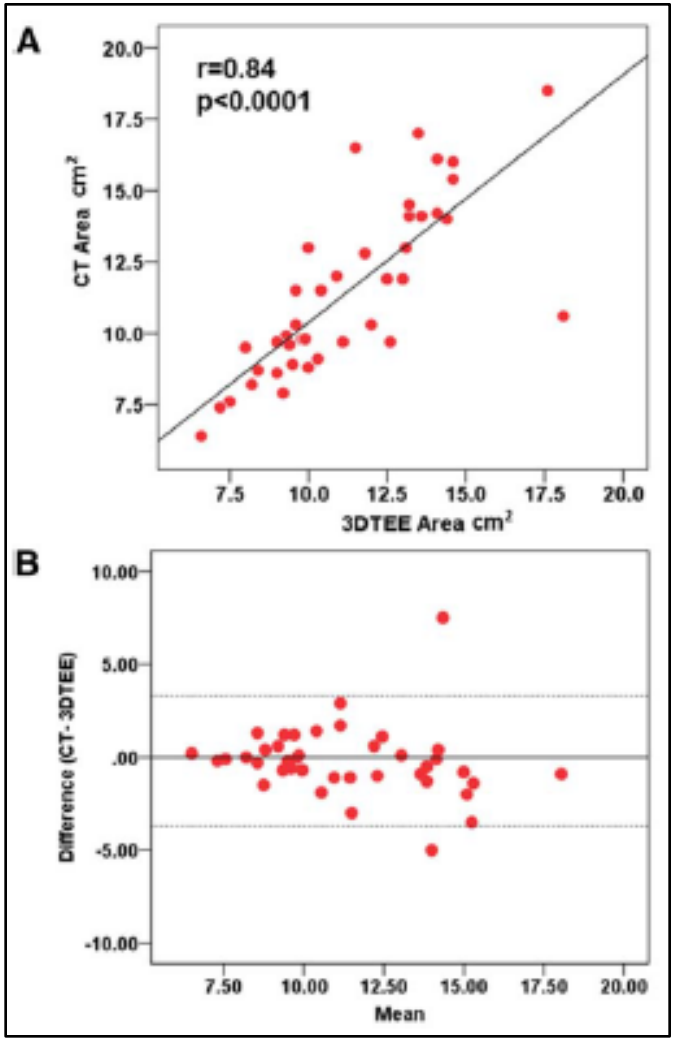
FIGURE 1 Schematic of Various TMVI Anchoring Mechanisms



Blanke et al. JACC CV Im 2015

Three-Dimensional Echocardiography Compared With Computed Tomography to Determine Mitral Annulus Size Before Transcatheter Mitral Valve Implantation

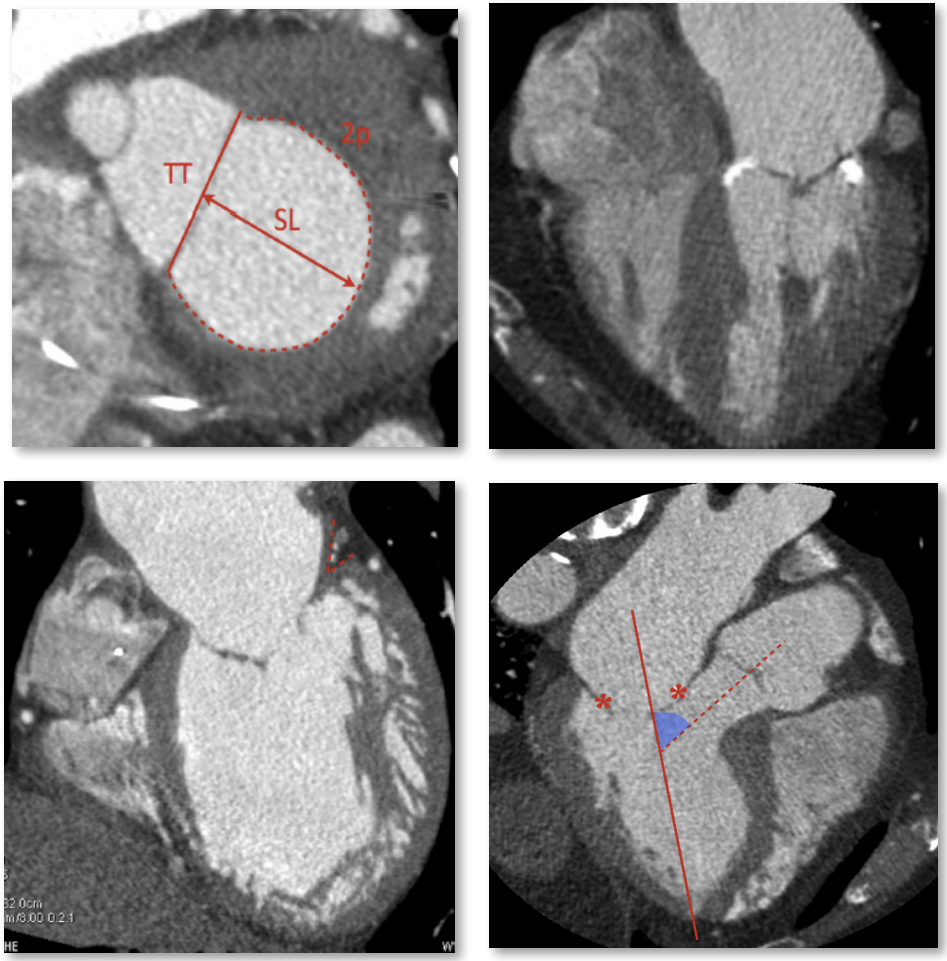




Mak G et al. Circ CV Imag 2016

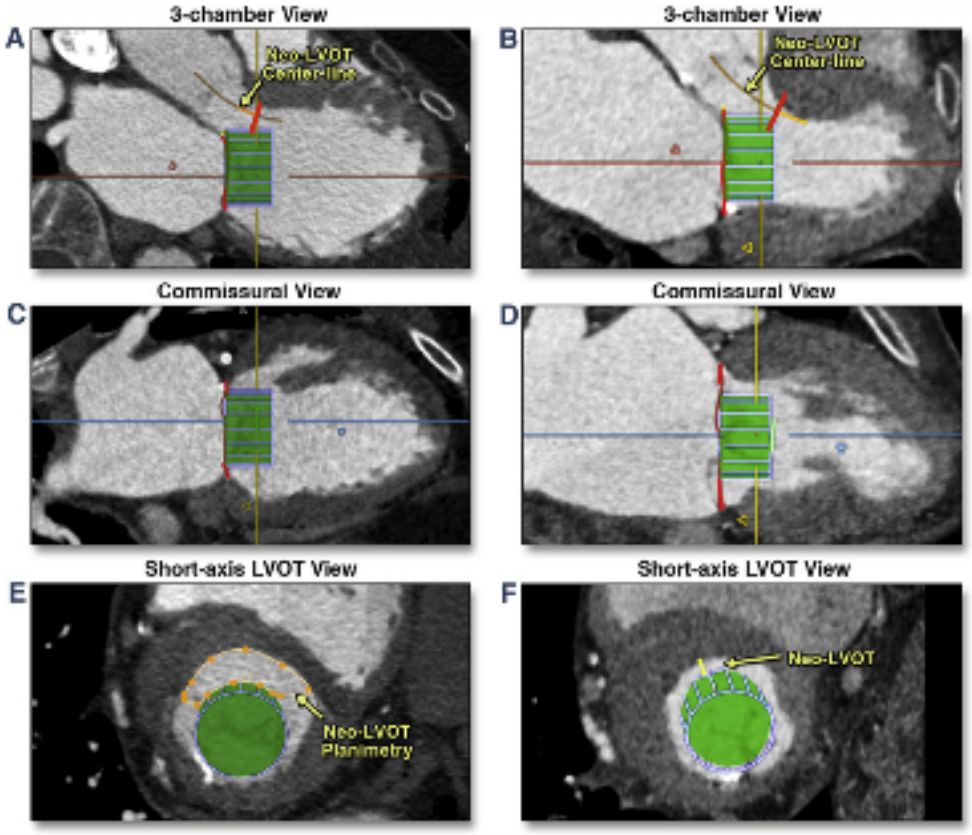
Transcatheter mitral valve interventions / CT

- Cross-sectional area, perimeter, and diameters of the annulus
- Annulus calcification
- Papillary muscle anatomy
- Landing zone and myocardial shelf
- Distance annulus/coronary sinus
- Distance annulus/circunflex
- Aorto-mitral angle



Mak G et al. Circ CV Imag 2016

Transcatheter mitral valve interventions / CT
Predicting LV obstruction – Virtual placement



- Characterization of a post-procedural "neo-LVOT."

- Factors that predict neo-LVOT obstruction - acute aortomitral angle, small LV cavity size, and basal septal hypertrophy

Blanke et al, JACC CV Imag 2016

Conclusions

- CMR and CT are useful and promising tools for precise and accurate assessment of functional mitral regurgitation
- These modalities provide information on anatomy, etiology, functional severity, tissue characterization, prognosis and procedure's planning, yet awaiting future developments