Reconstruction of the Aortic Valve and Root: A Practical Approach
September 7-9-2022Homburg/Saar, Germany

Reimplantation is the best root repair

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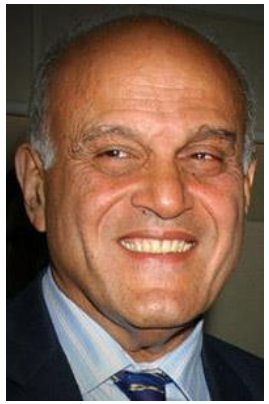
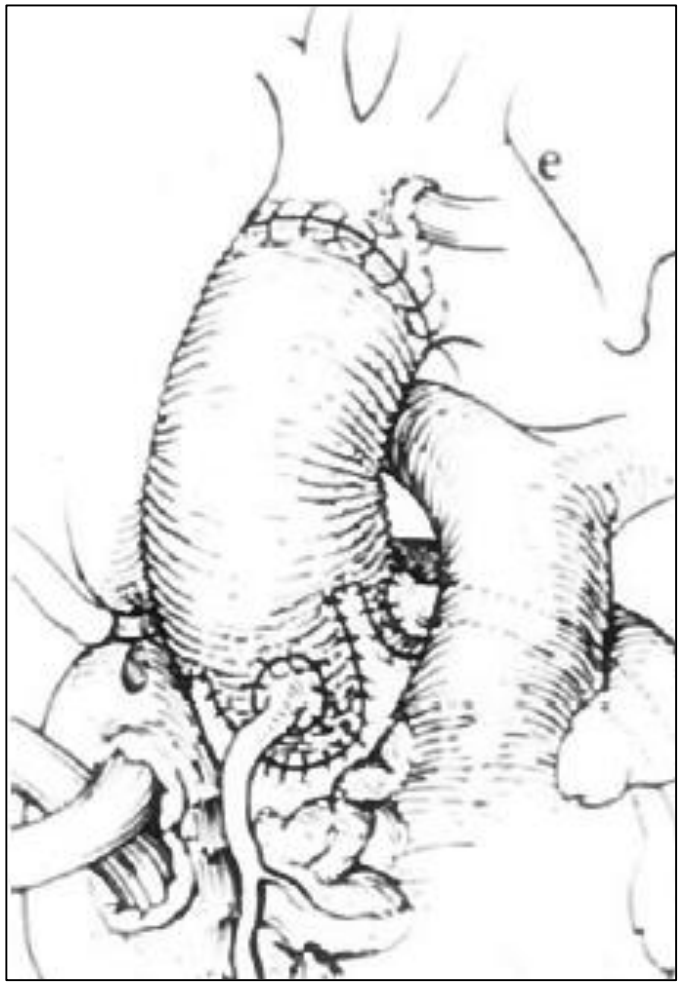
The origin of valve sparing root replacement operations

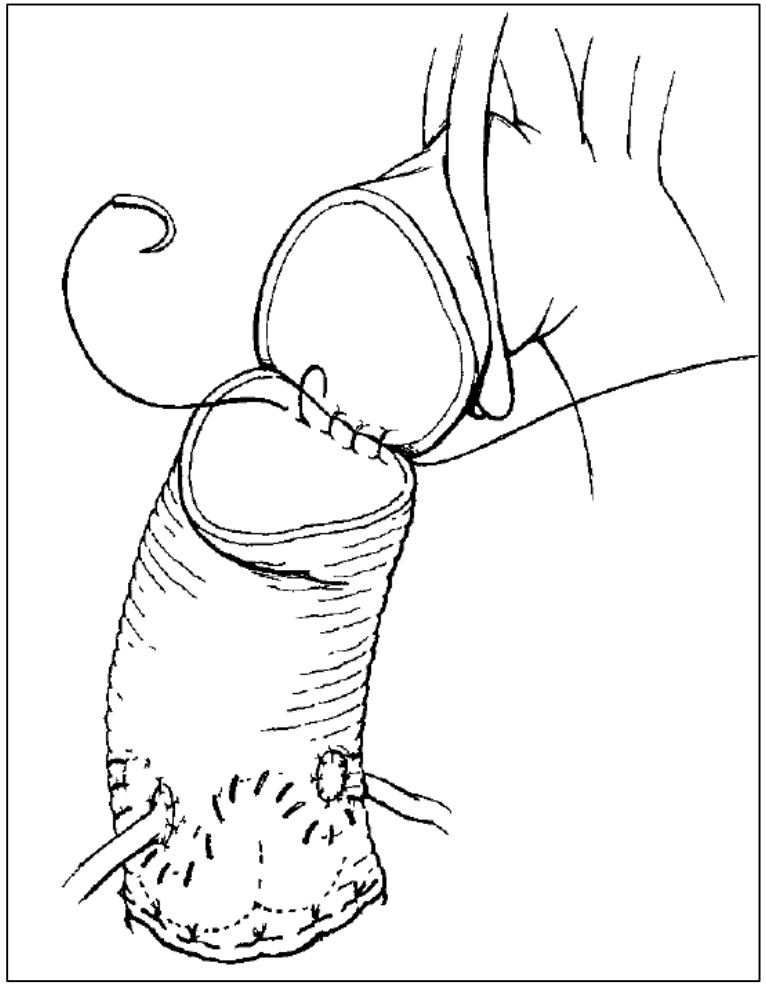


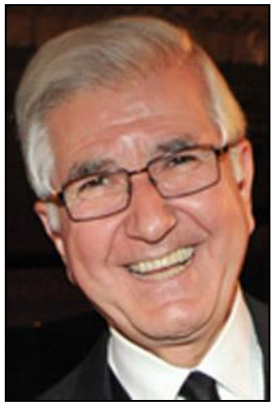
Sir M. Yacoub

Remodeling technique (1983)



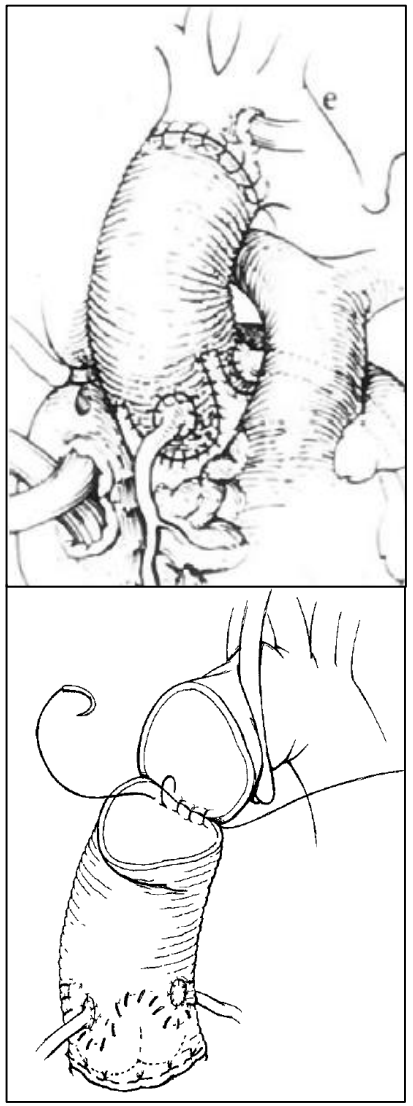
Reimplantation technique (1992)



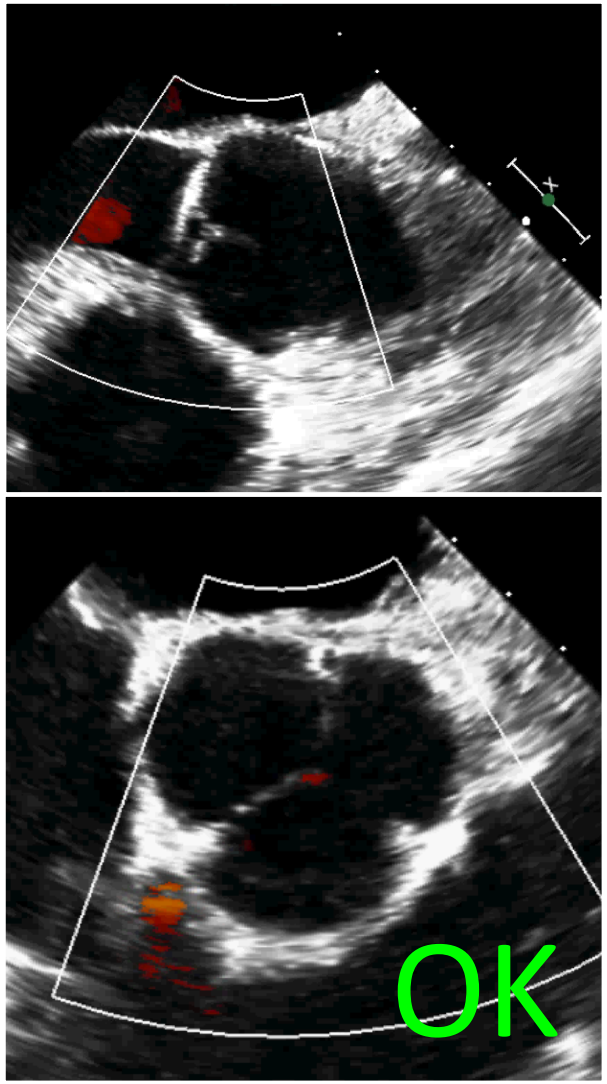


Prof. T. David

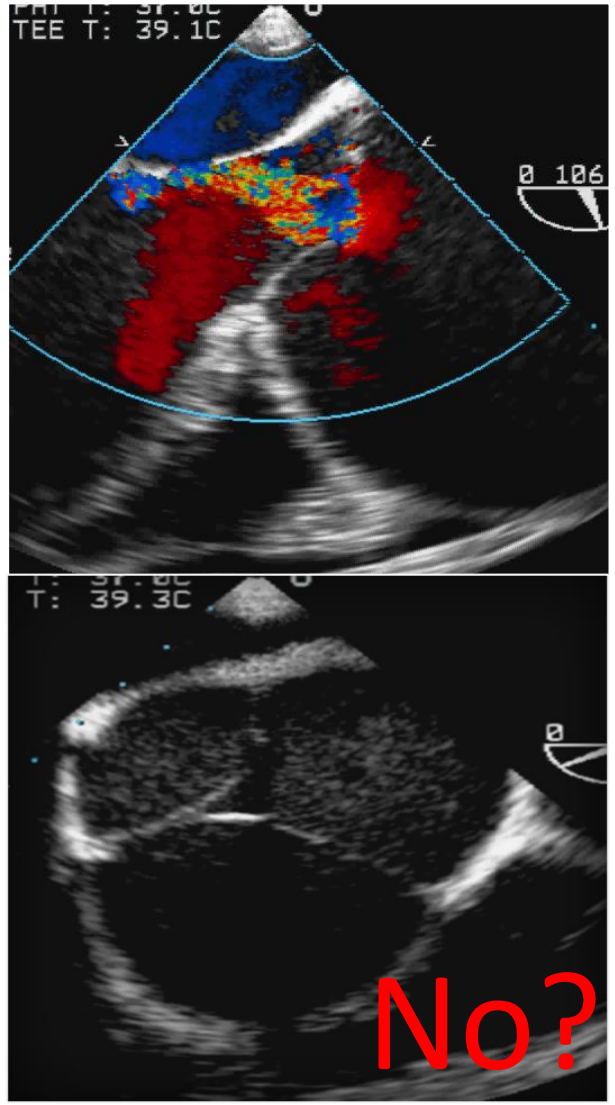
VSRR was developed to treat **aortic root aneurism in TAV** !



Root aneurism/no AI

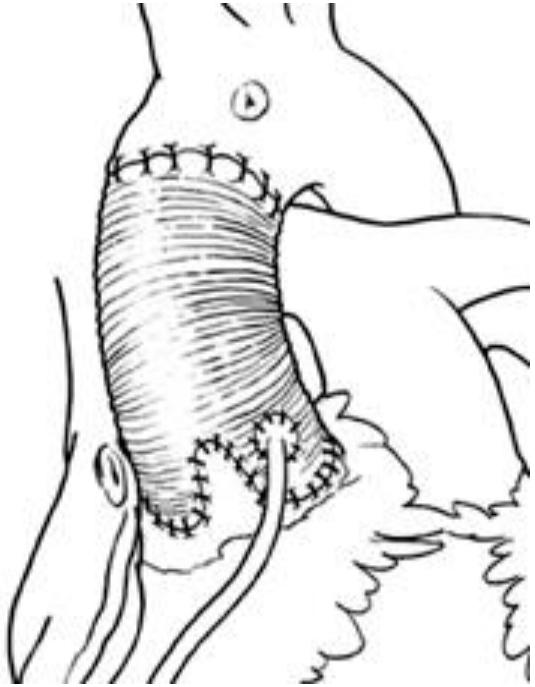


Root aneurism + AI



And the debate started…

Remodeling



- Faster
- Less root dissection
- Only 1 suture line

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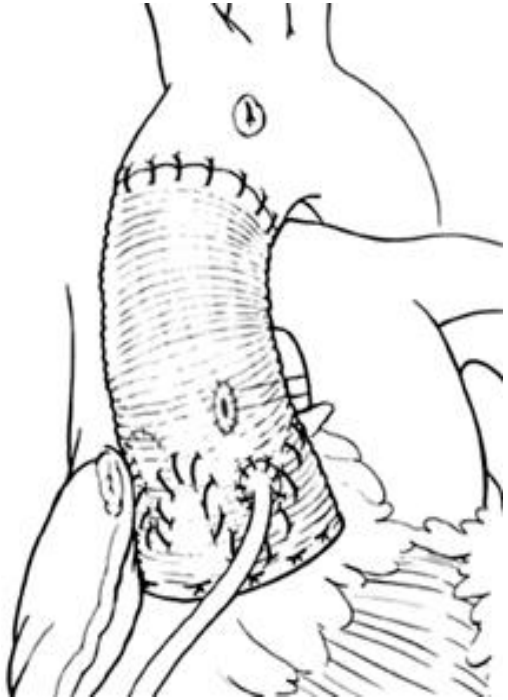
Reimplantation

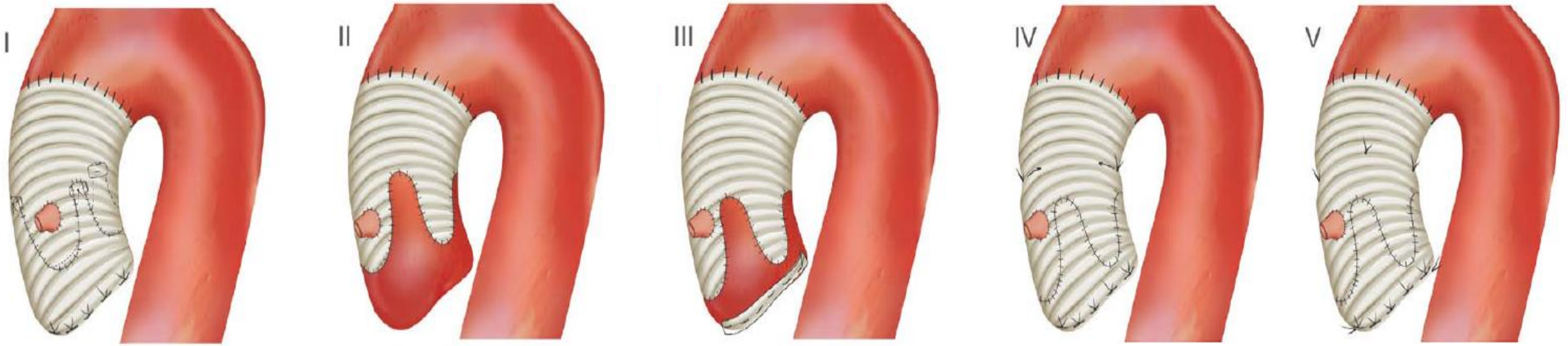


- More hemostatic
- More reliable
- Better Stabilisation in Marfan

No long term outcomes !

Several modifications proposed

David's Operations (1992-2001)



(Reimplantation in straight tube)

(= Remodeling)

(= Remodeling + partial external ring)

(Reimplantation with neosinuses)

Kari F.A. Circ 2013

VSRR: Why we do it?
Hospital mortality

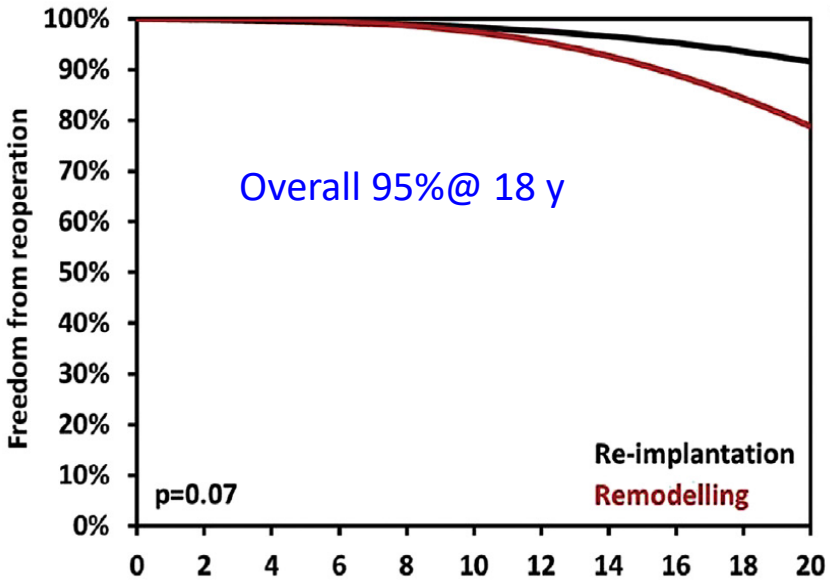
12% AAD	• 1%	(4/371 pts Reimpl. & Remod.)	T. David JTCVS 2014
8% AAD	• 2%	(6/747 pts Remodeling)	H-J Schäfers EJCTS 2015
10% AAD	• 2%	(4777 pts Metanalysis)	*B. Arabkhani ATS 2015*
Elective	• 0.3%	(1/381 pts Reimplantation)	G. El Khoury, updated series 2000 – 2015
6% AAD	• 0.7%	(1/146 Marfan Reimpl. & remod.)	T. David JACC 2015
4% AAD	• 0%	(0/98 Marfan Reimpl. & remod.)	J. Price JTCVS 2016

1. SAFE !

VSRR: Why we do it?

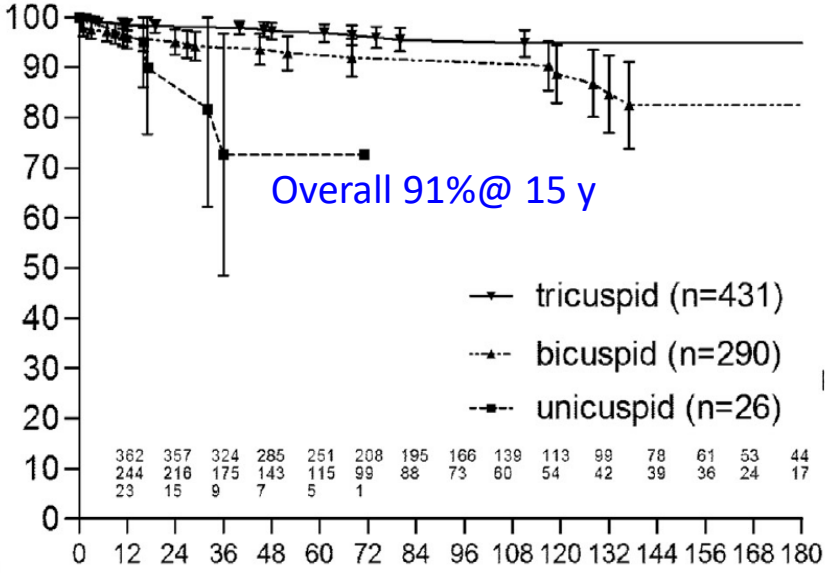
Freedom from Reoperation

Reimpl. & Remod.



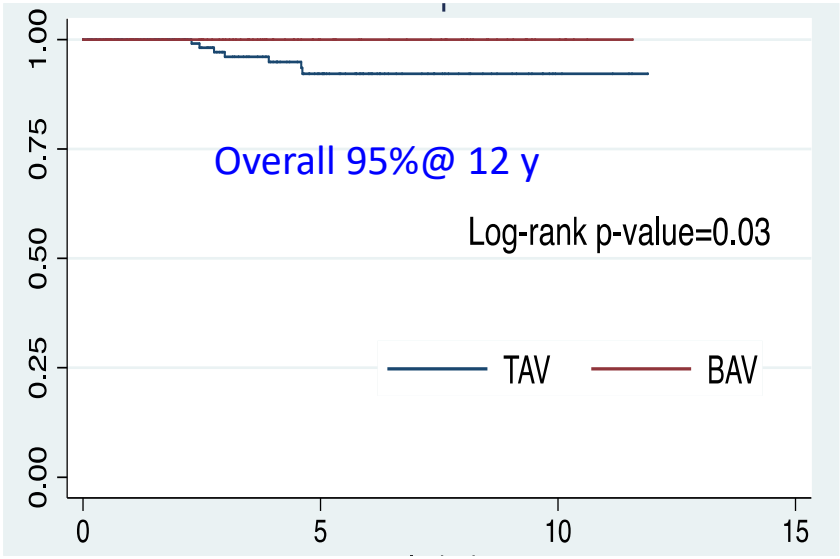
T. David JTCVS 2014

Remodeling



H-J Schafers EJCTS 2015

Reimplantation



S. Mastrobuoni STSA 2014

2. Durable !

VSRR: Why we do it?

Results

VSRR

Pooled Late Outcome Events	LOR + 95% CI
Late mortality	1.53 (1.19–1.96)
Reoperation on aortic valve	1.32 (1.0–1.74)
Hemorrhage	0.23 (0.13–0.42)
Thromboembolism	0.41 (0.22–0.77)
Endocarditis	0.23 (0.11–0.51)
MAVRE	1.66 (1.24–2.23)

0.8%

Bentall

Pooled Late Outcome Events	LOR + 95% CI
Late mortality[a]	2.02 (1.77–2.31)
Valve-related mortality	0.46 (0.36–0.59)
Root reoperation[b]	0.46 (0.36–0.59)
Valve reoperation	0.30 (0.22–0.41)
Hemorrhage	0.64 (0.47–0.87)
Thromboembolism	0.77 (0.60–1.00)
Endocarditis	0.39 (0.33–0.46)
MAVRE	2.66 (2.17–3.24)

B. Arabkhani, JJ. Takkenberg ATS 2015
A. Mookhoek, JJ. Takkenberg ATS 2016

VSRR: Why we do it?

Why do a Valve-Sparing Reimplantation Procedure?

1. SAFE
2. Durable
3. Excellent Long-Term Survival
4. Low VRE

General Principles

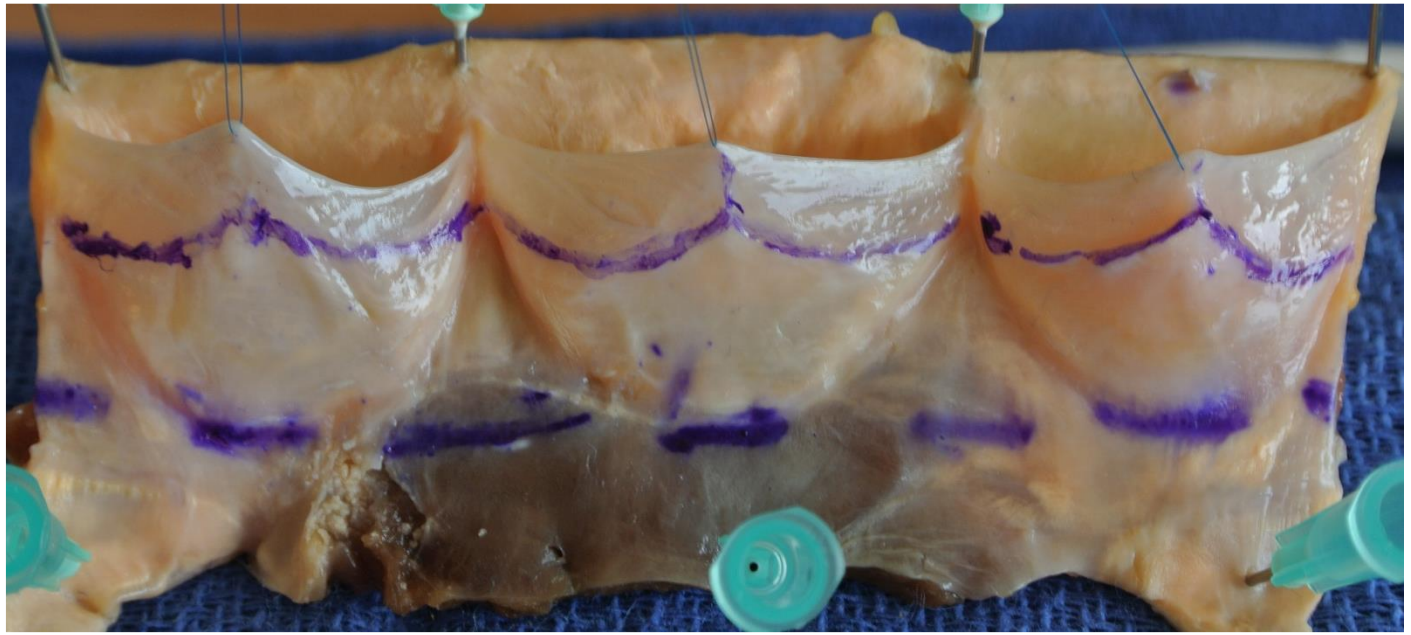
1. Restore and preserve cusp geometry and motion

+

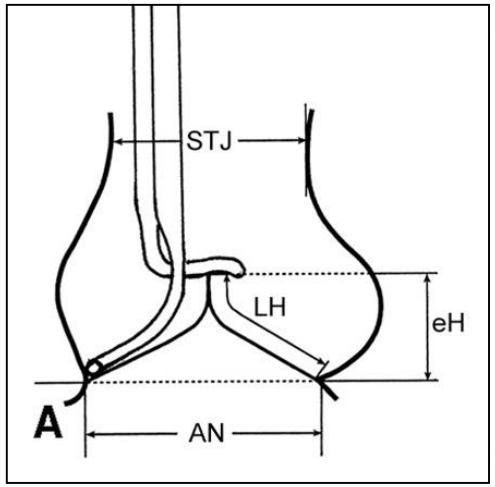
2. Remodel and stabilize the FAA

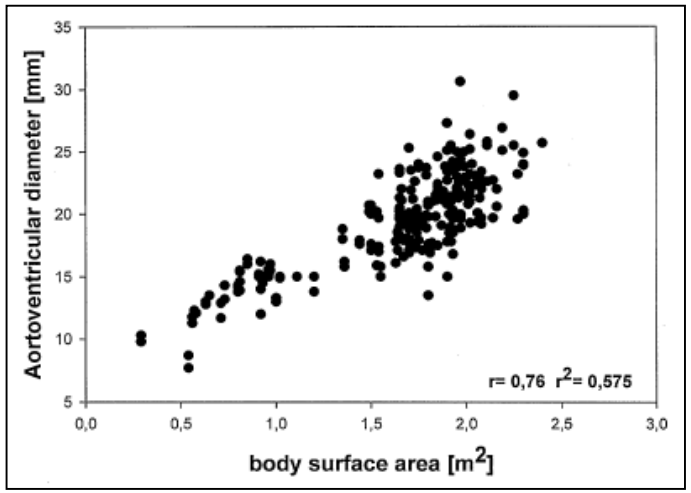
↓

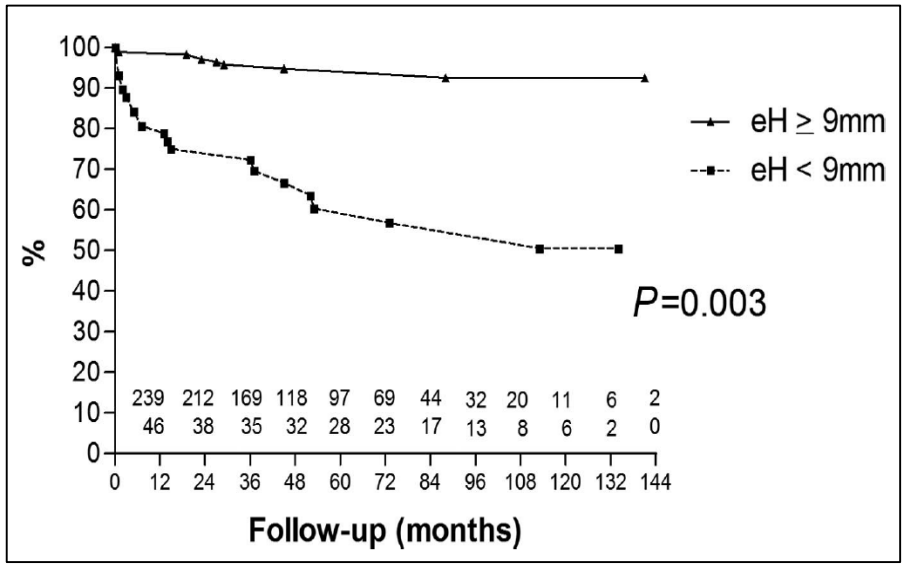
Optimal area of coaptation, stable over time



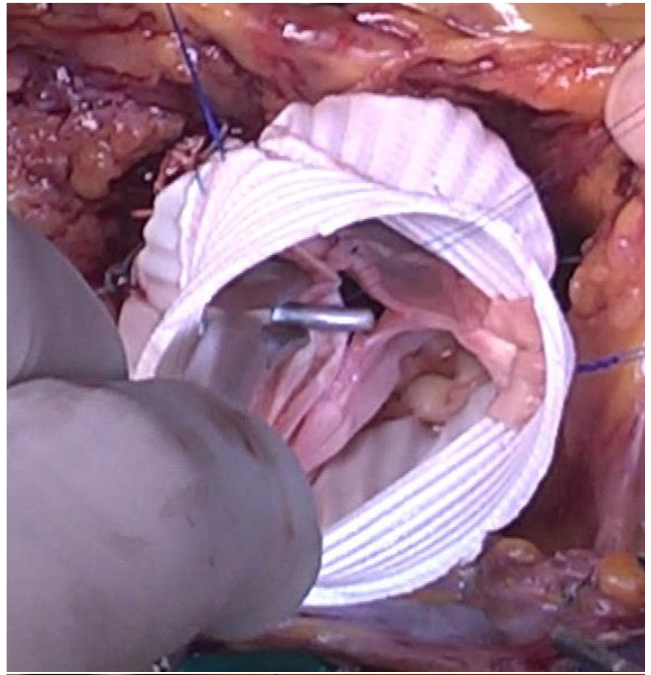
Optimal Coaptation

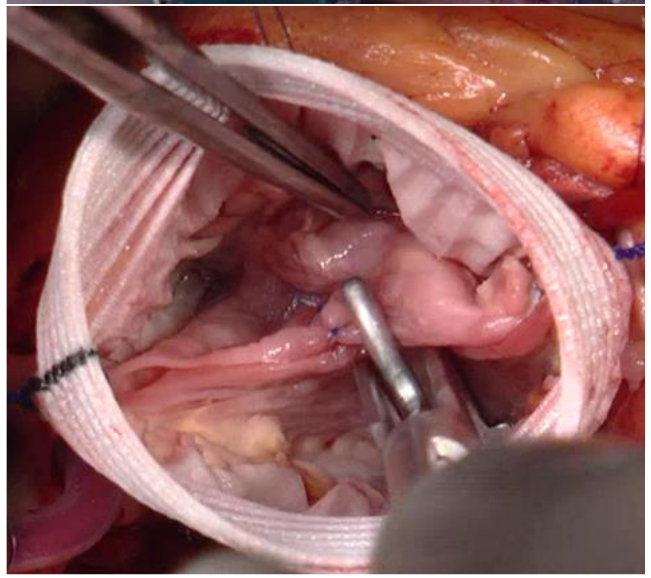






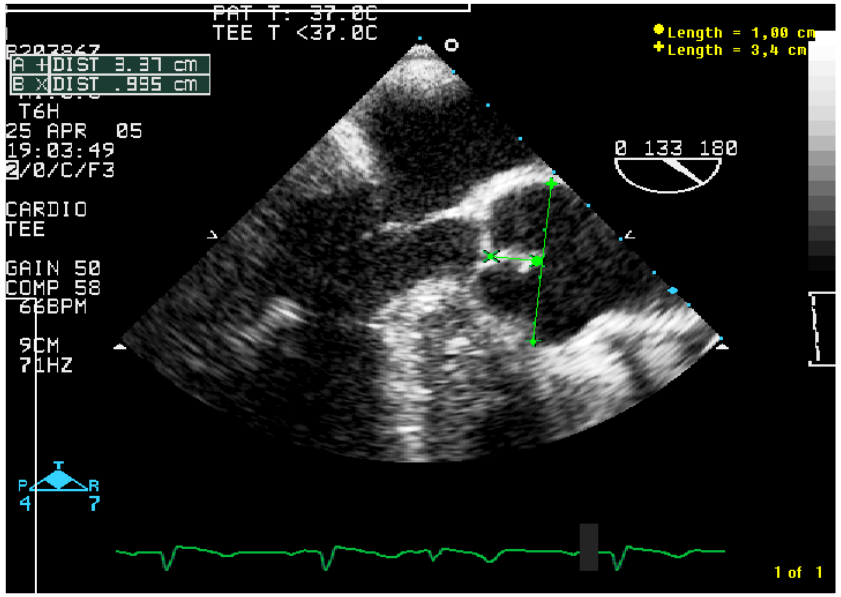
Schafers H.J. JCTVS 2006
Bierbach B.O., EJCTS 2010
Aicher D. Circ. 2011

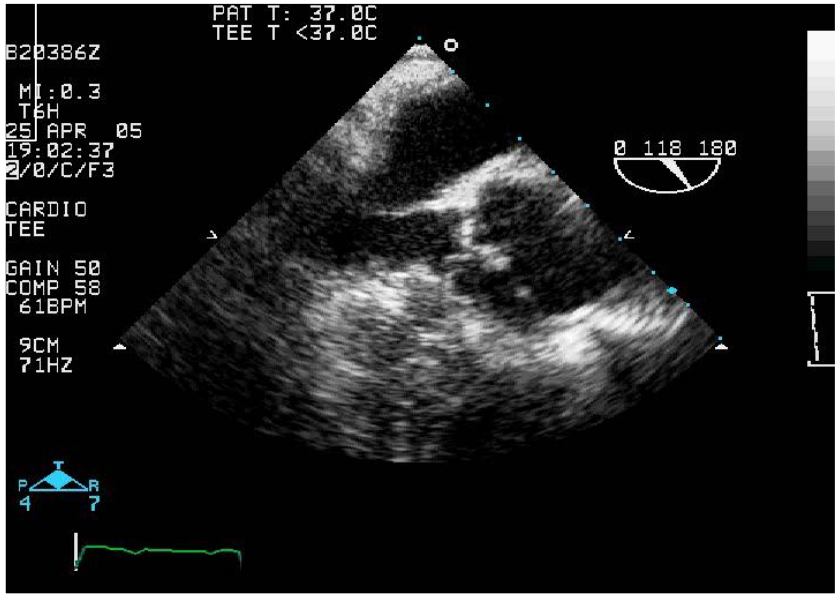




Optimal Coaptation & Stabilisation

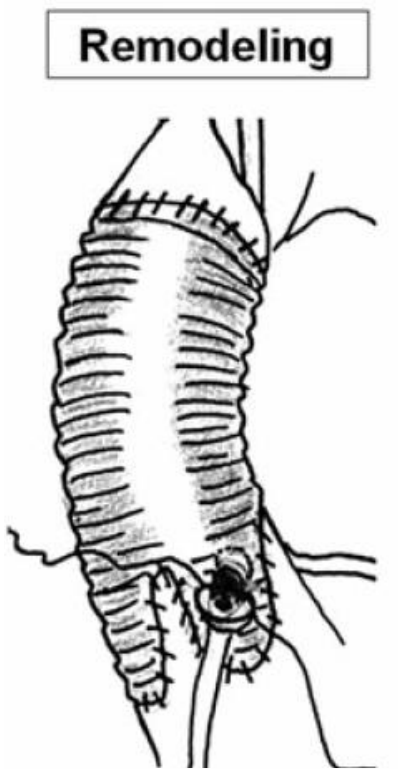
- Effective height (eH) ≥ 9 mm
- Coaptation length ≥ 4 mm
- Circumferential annuloplasty VAJ >26
- No residual AR



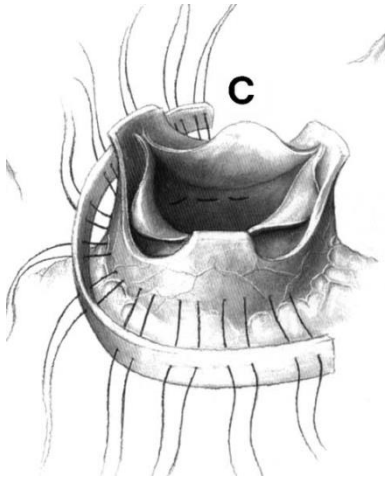


Pethig K. ATS 2002
le Polain de Waroux JB. JACC Card. Im. 2009
Bierbach BO. EJCTS 2010
Aicher D. Circ. 2011
De Kerchove L. JTCVS 2011

Evolution of the Remodeling technique

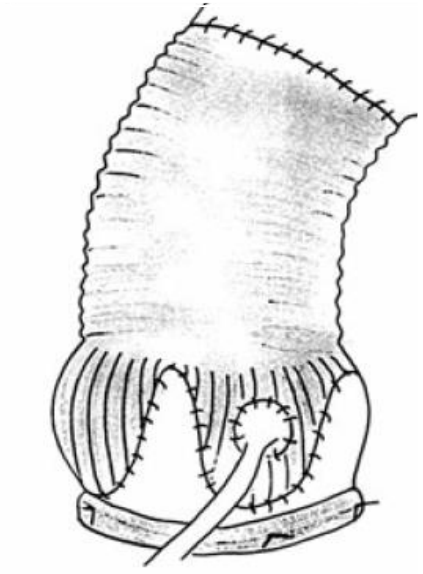


Partial external band



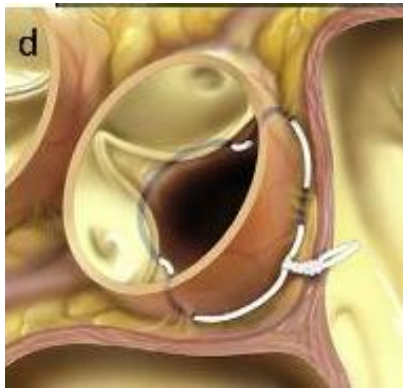
T. David 1996

Circumferential external band



E. Lansac 2006

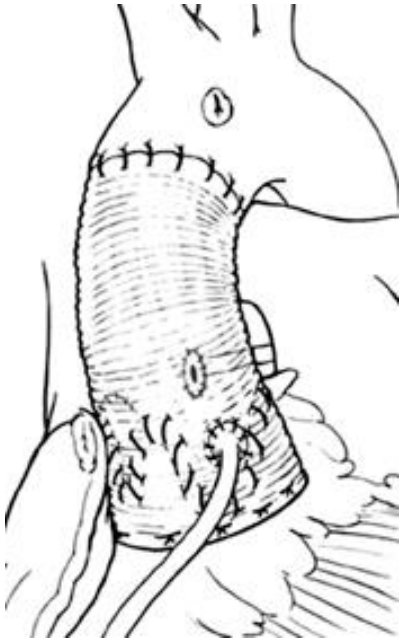
Suture Annuloplasty



HJ. Schäfers 2013

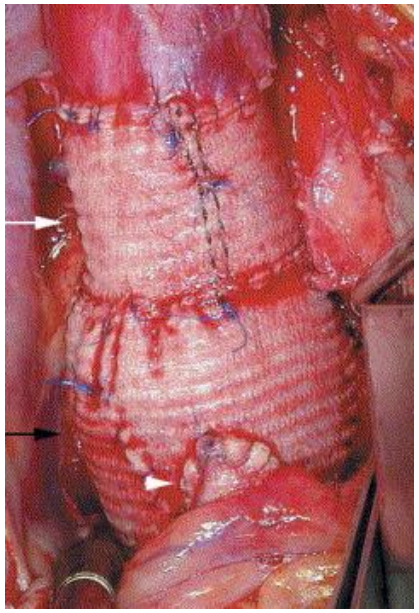
Evolution of the Reimplantation technique

Reimplantation



David V

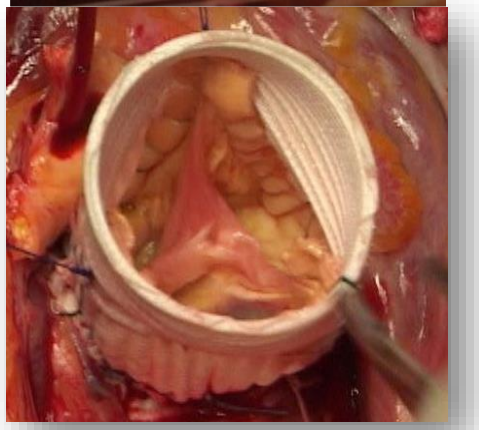
Stanford Modification



C. Miller

Sinus Graft

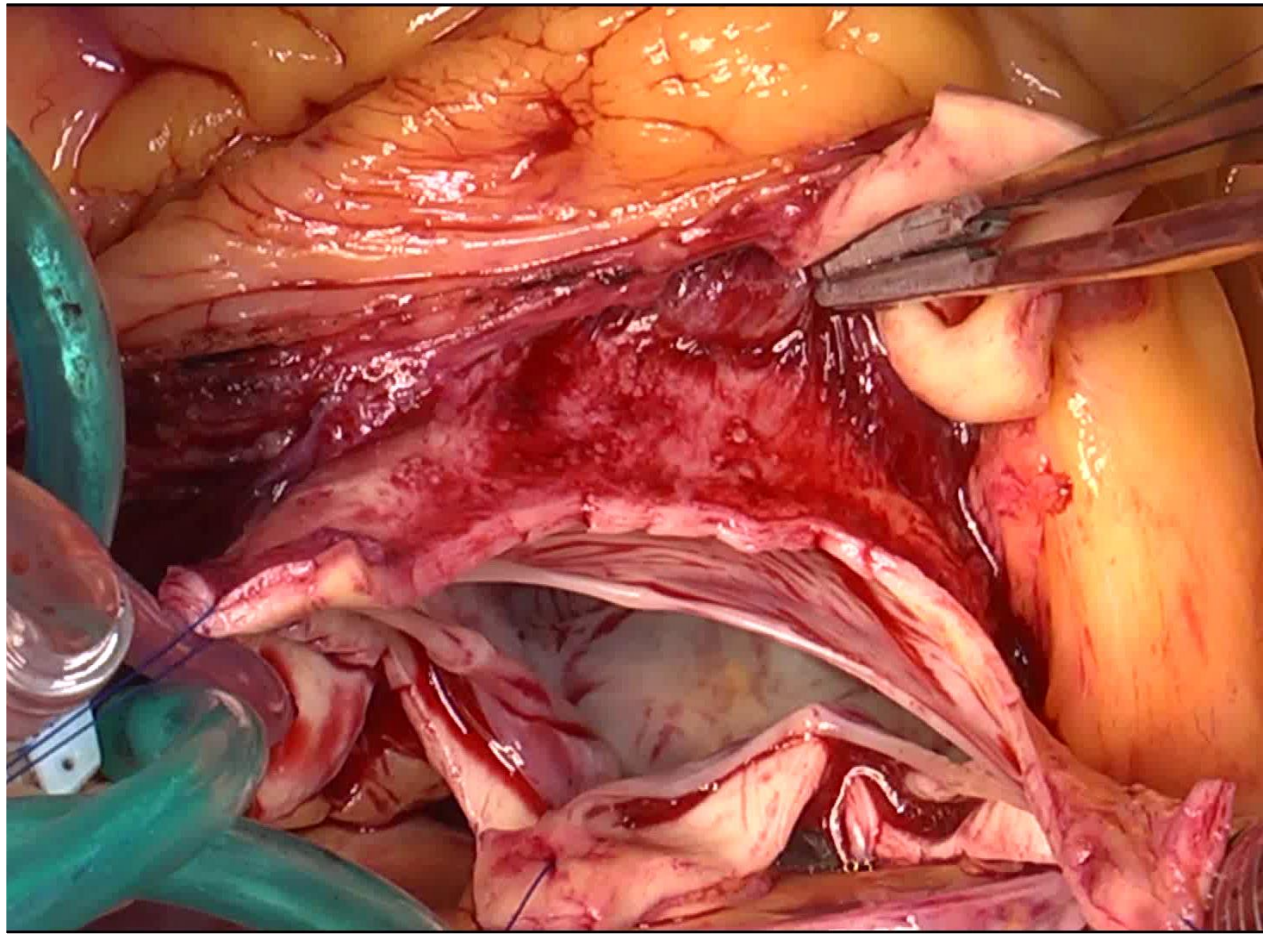
Valsalva®



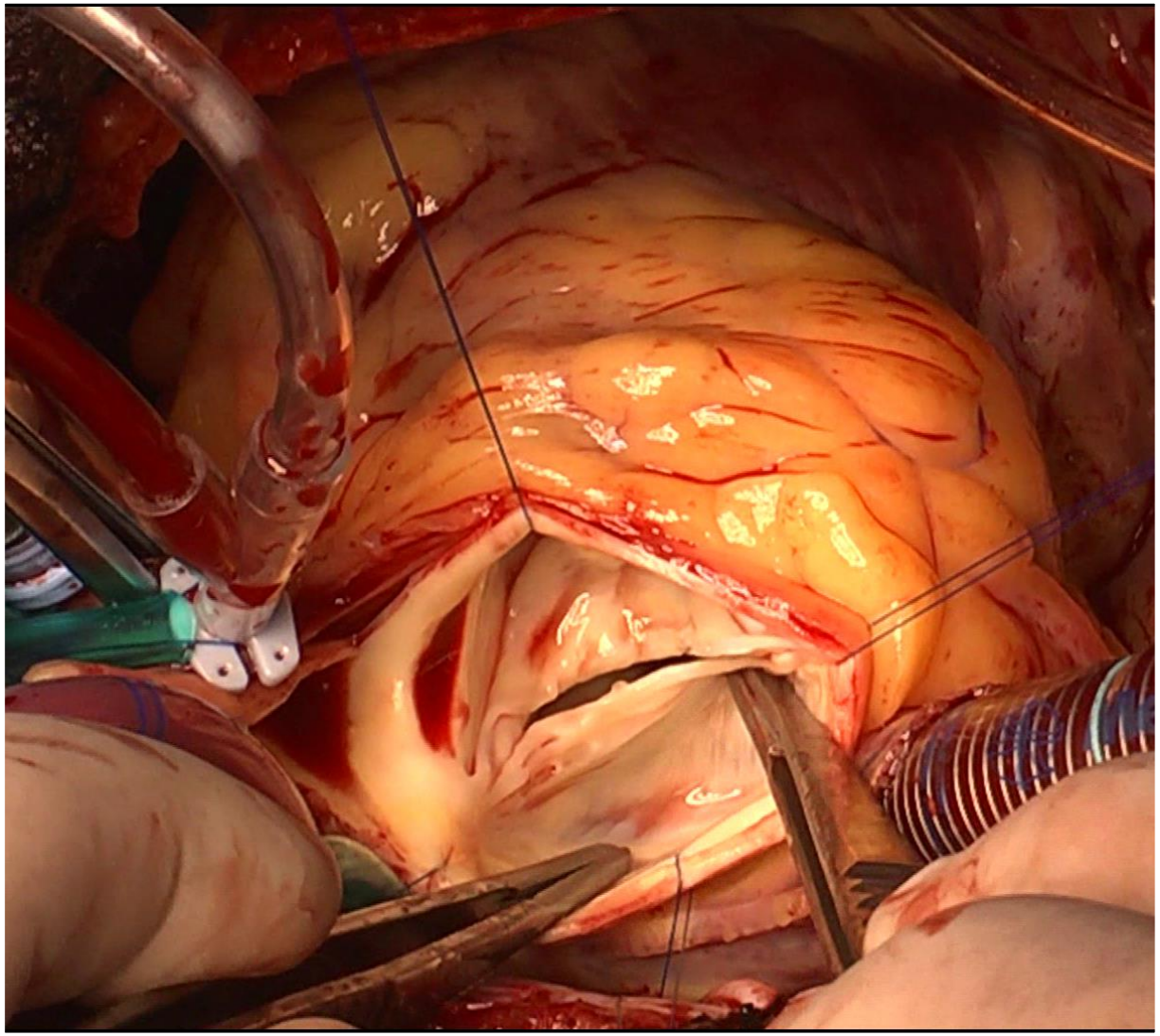
R. De Paulis 2002

Deep External Root dissection for VSR or External Ring

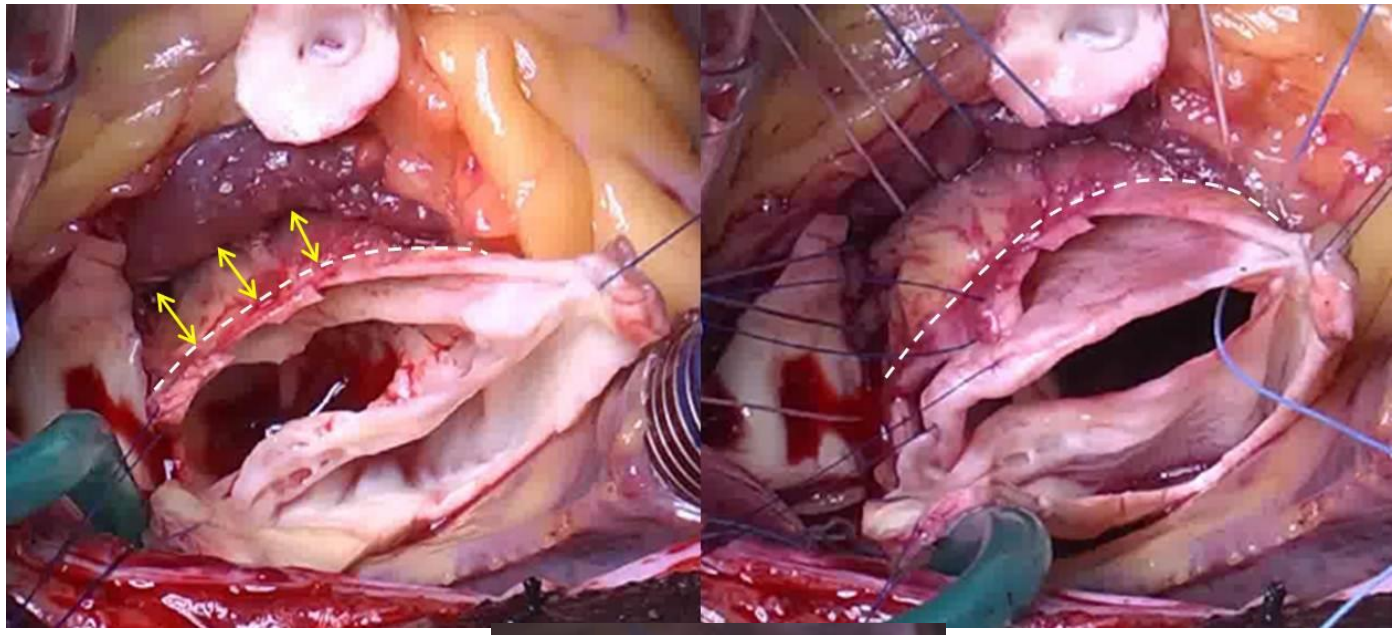
TAV

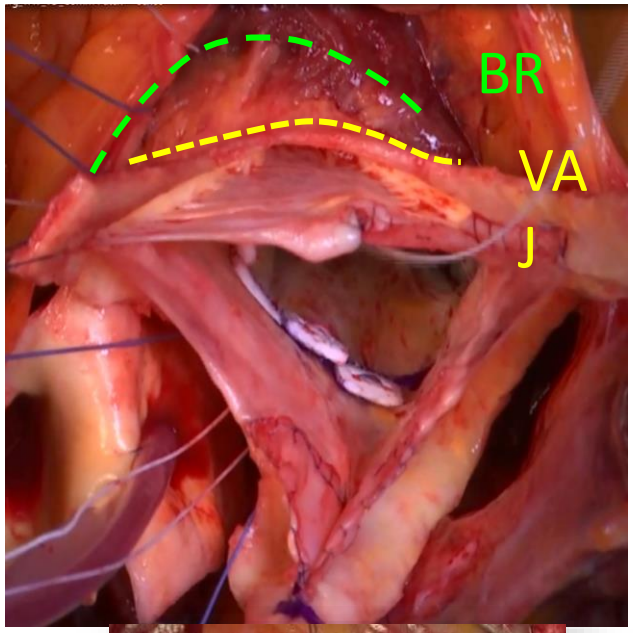


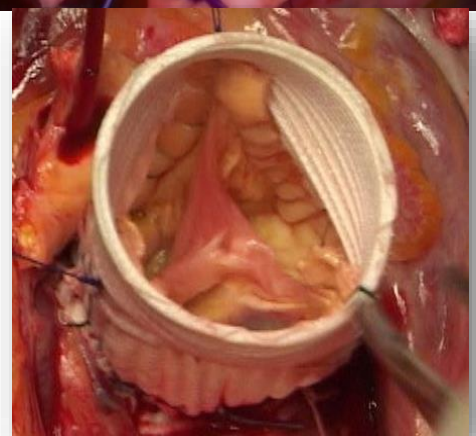
BAV



Brussels AV repair: ***Why is VSR so efficient?***

1. Circumferential prosthetic annuloplasty ⟶ **Stable over time**
2. 
3. 

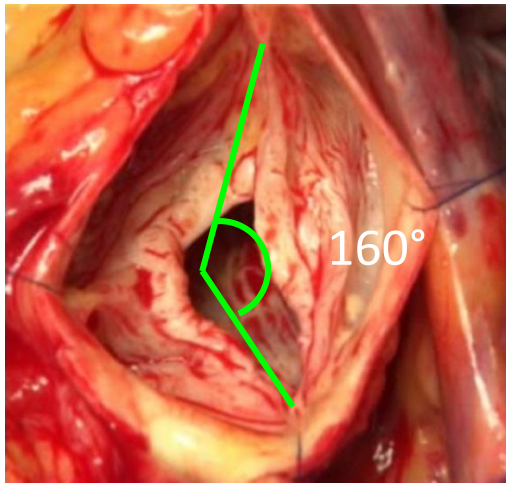


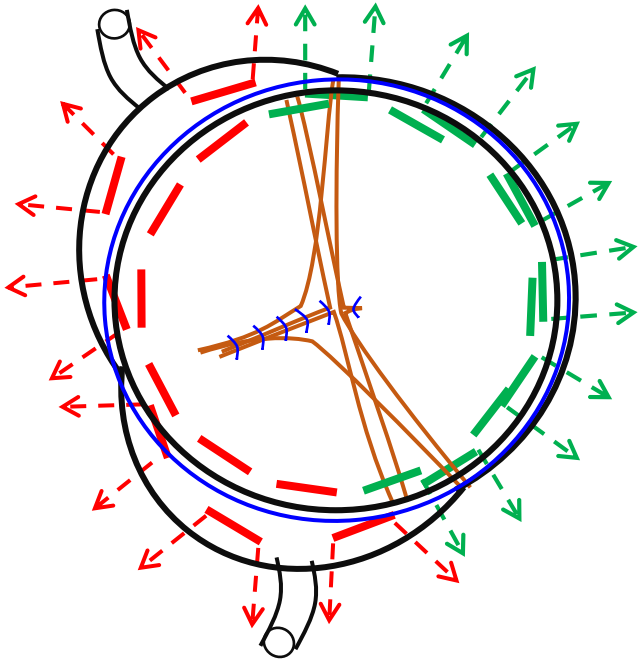


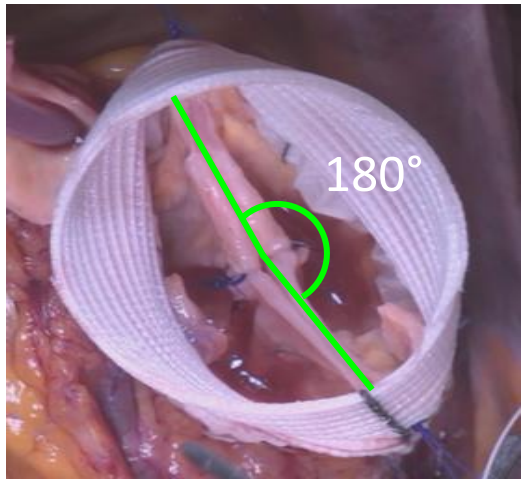
Brussels AV repair: ***Why is VSR so efficient?***

1. Circumferential prosthetic annuloplasty ⟶ **Stable over time**
2. Remodel BAV geometry to 180°
3. Optimal Coaptation

“Assymetric annuloplasty”

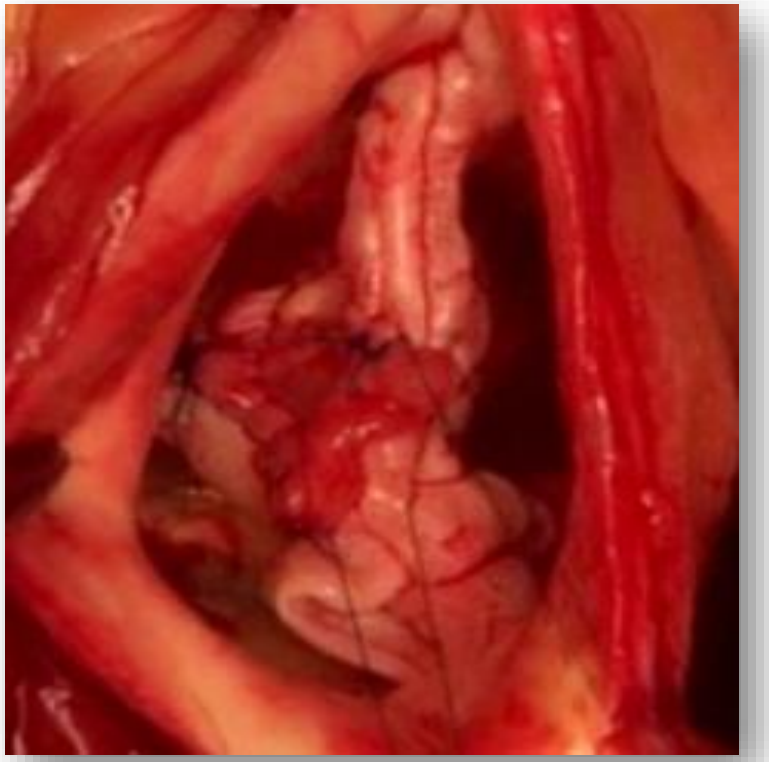


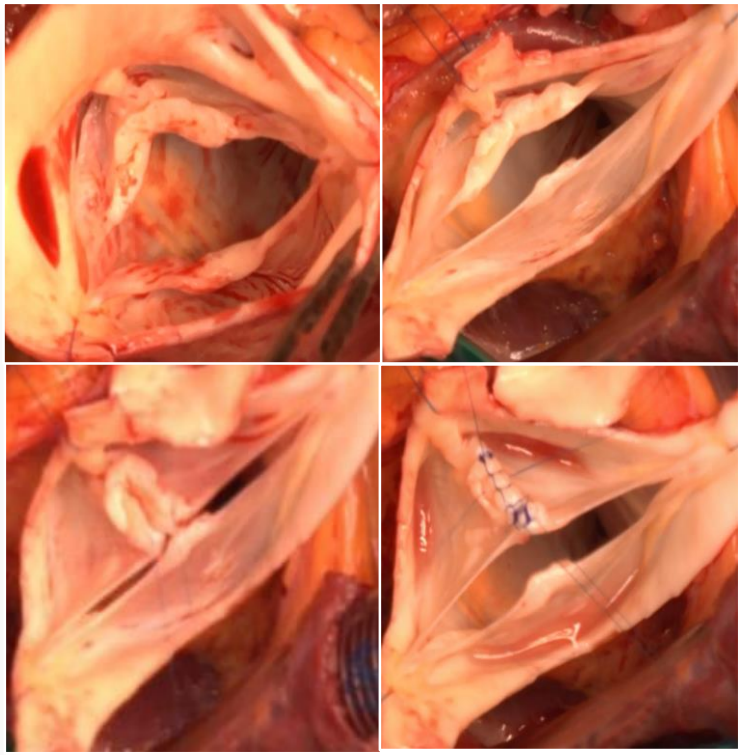


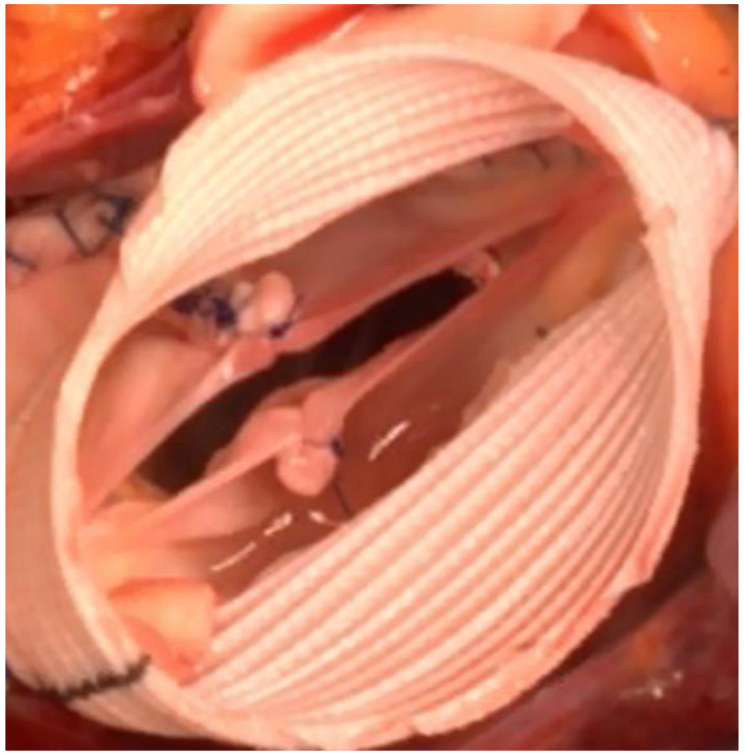


Brussels' BAV repair: *Why is VSR so efficient?*

1. Circumferential prosthetic annuloplasty → **Stable over time**
2. Remodel BAV geometry to 180° → **Durable configuration**
3. Optimal Coaptation → **Reduce the need of patch**







Brussels' BAV repair: ***Why is VSR so efficient?***

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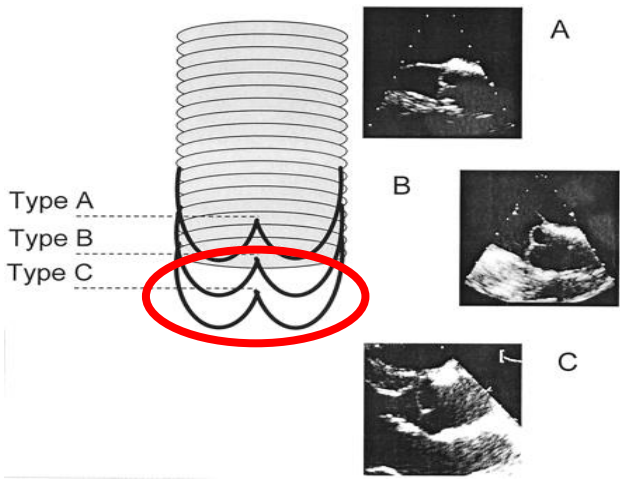
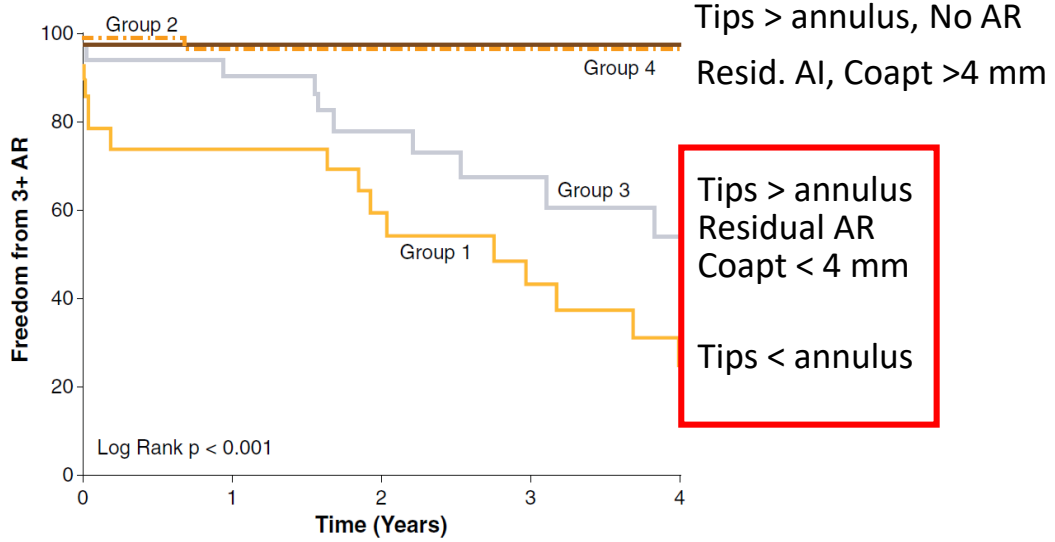
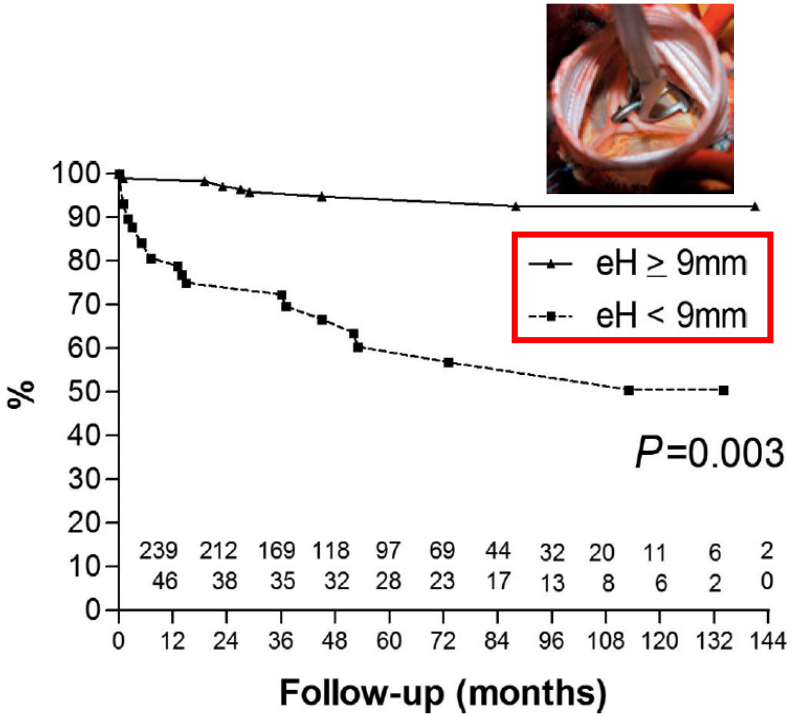


Pethig K. ATS 2002

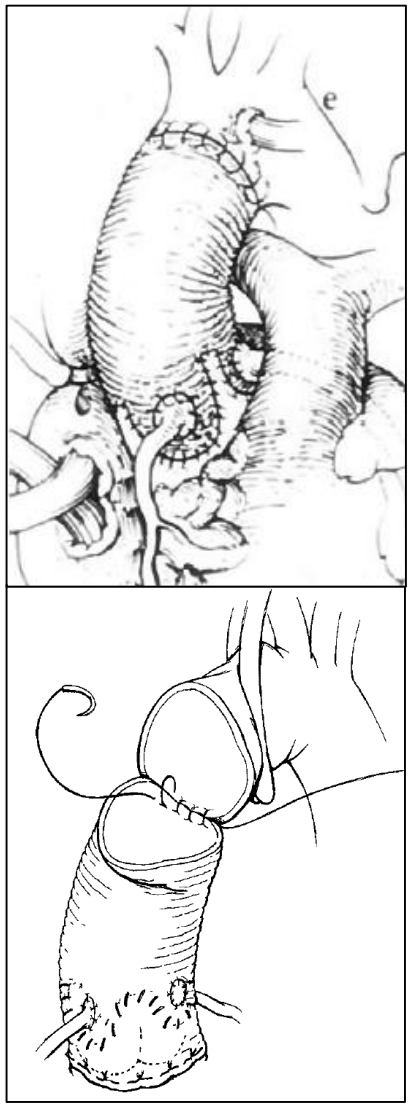


le Polain JB. JACC Card. Im. 2009

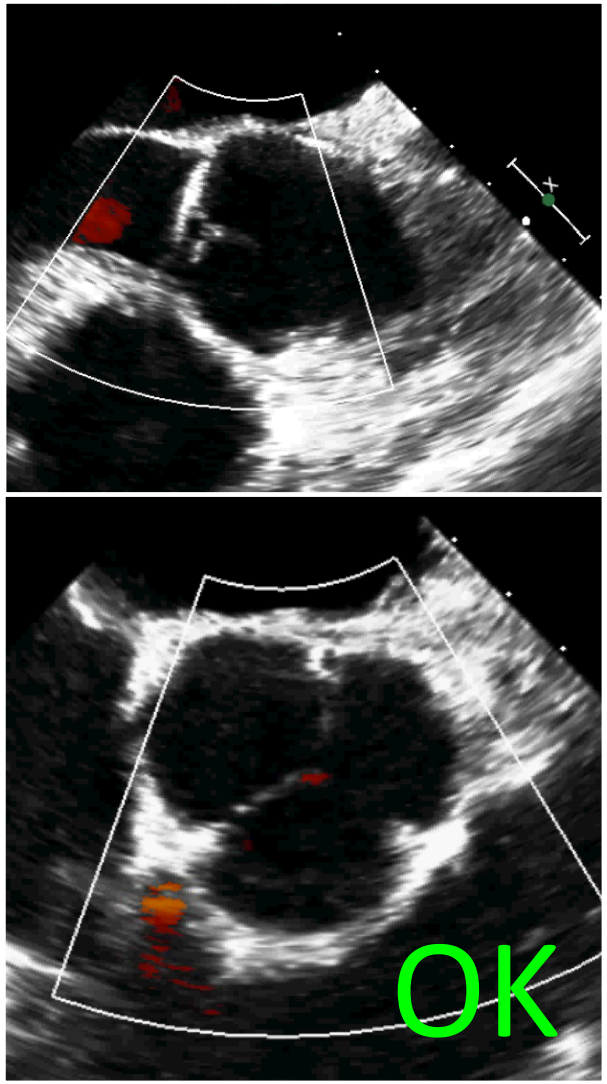


Aicher D. Circ. 2011

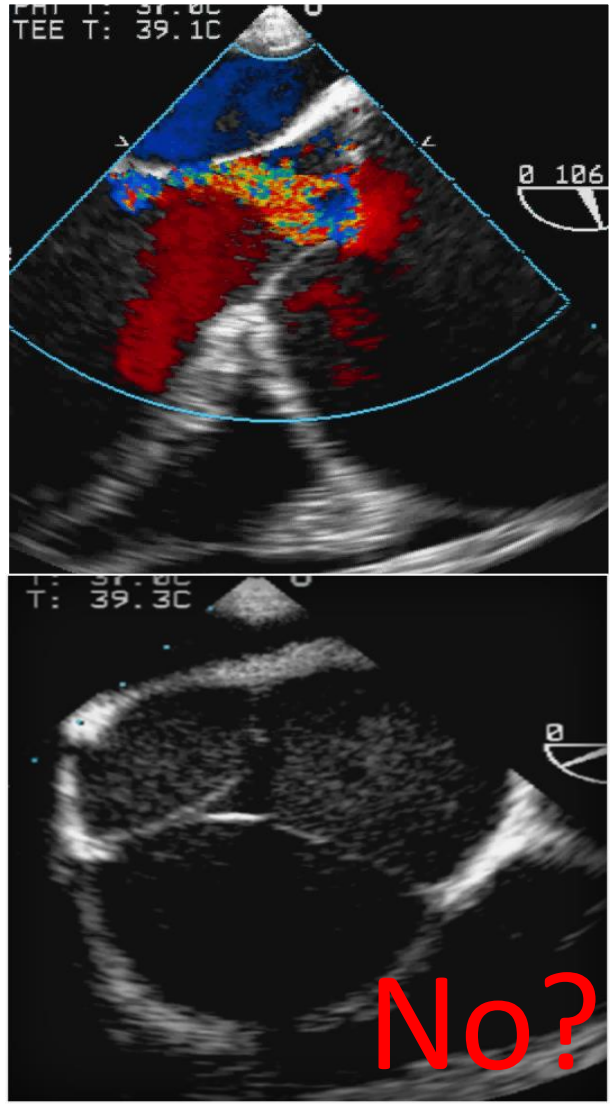
VSRR was developed to treat **aortic root aneurism in TAV** !

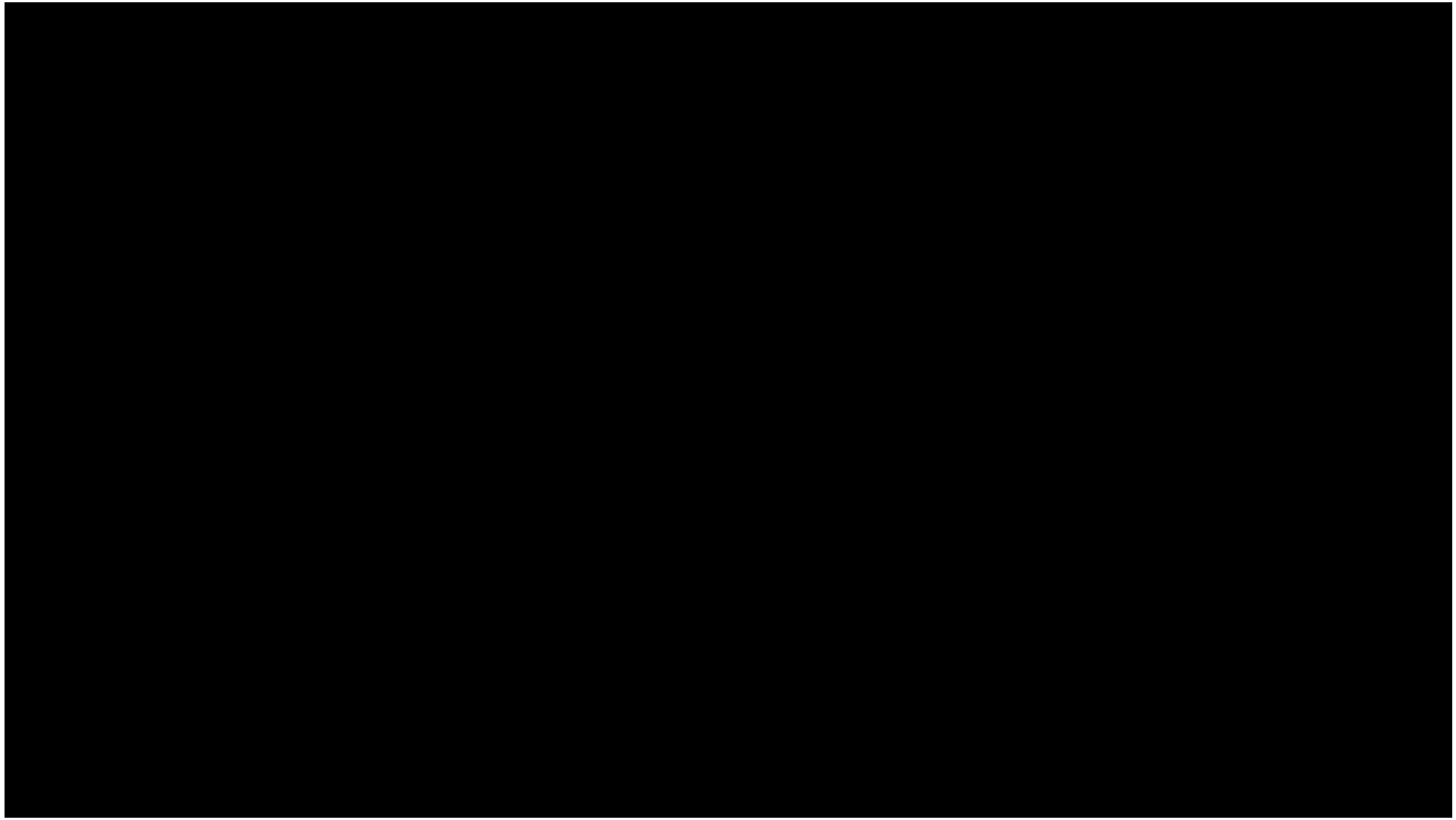


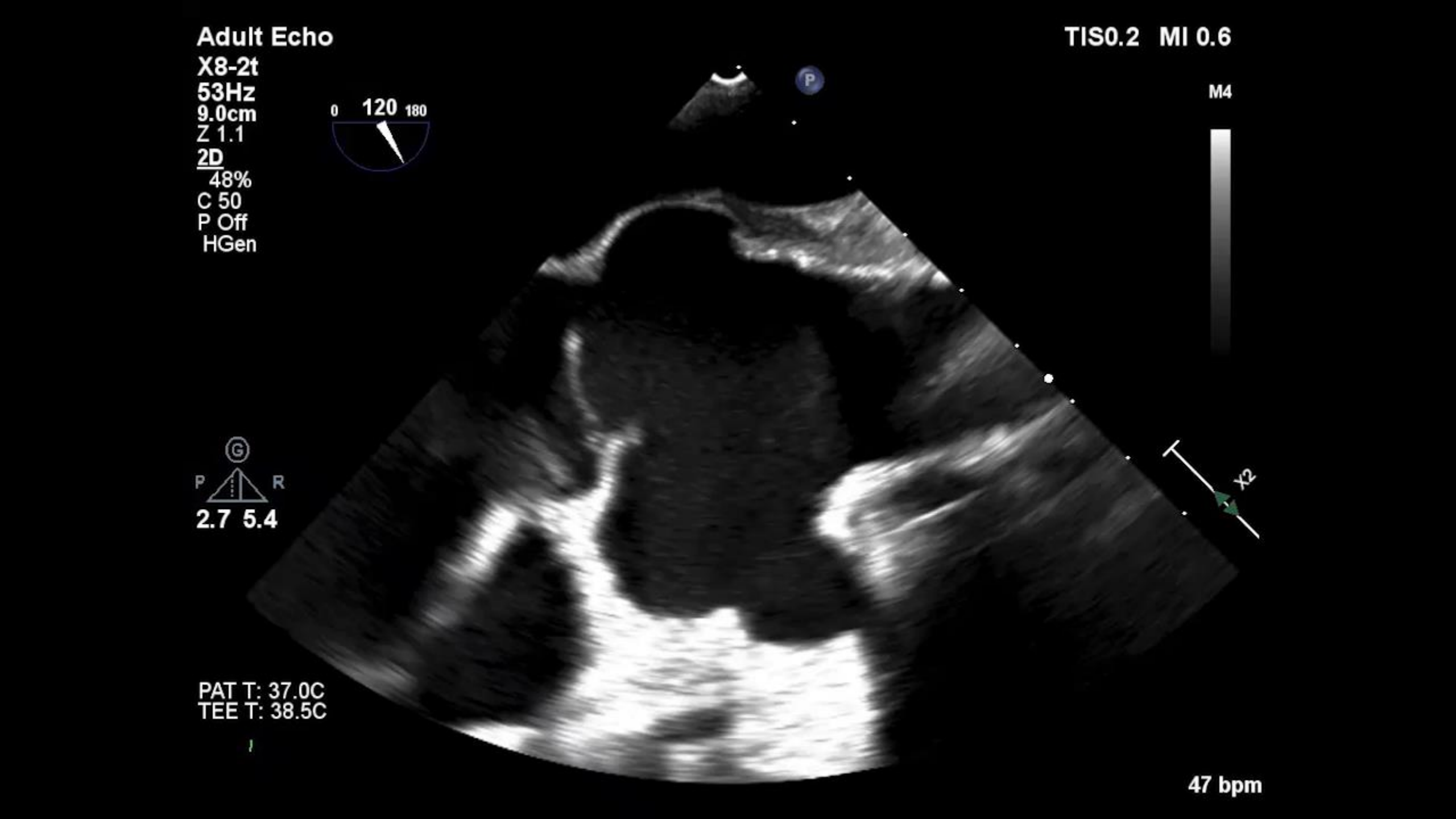
Root aneurism/no AI



Root aneurism + AI






Adult Echo
X8-2t
53Hz
9.0cm
Z 1.1
2D
48%
C 50
P Off
HGen
0
120
180
TIS0.2 MI 0.6
M4
P
G
P
R
2.7 5.4
X2
PAT T: 37.0C
TEE T: 38.5C
47 bpm

VSRR: *Why Reimplantation should be preferred*

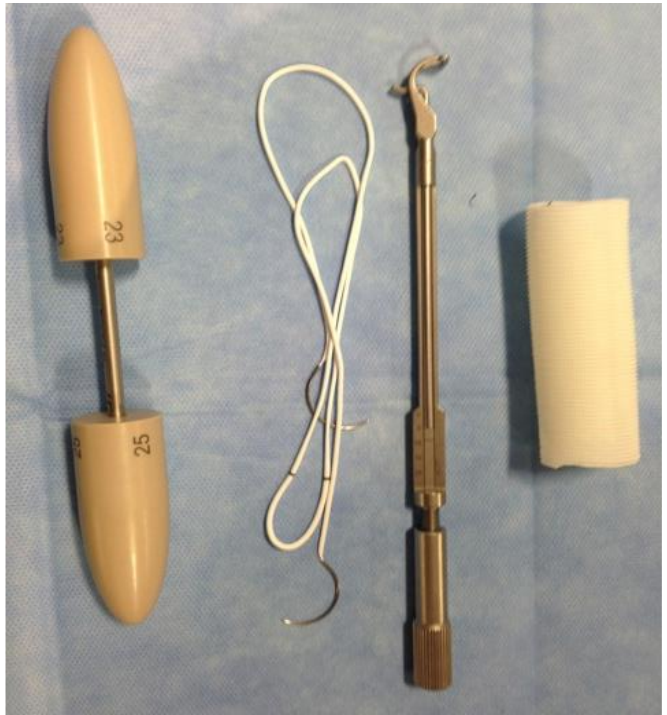
- Reimplantation techniques:
  - ✓ Safe and reproducible, disseminated worldwide
  - ✓ Proven long term durability in TAV, BAV, Marfan, dissection and in AI !
  - ✓ One sizing, one device (graft)
  - ✓ Ability to modify valve geometry (→ 180°symmetric configuration)

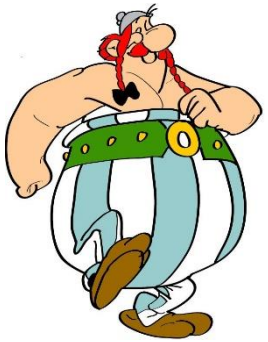
- Remodeling alone ok if no CTD, no or few central AI, no annulus dilatation !

VSRR: *Wathever the technique you choose,* ***do a Reimplantation !***

Brussels Gallic's Technique

Homburg Gallic's technique





Paris Gallic's technique

Highly selected population

Results of aortic valve–sparing operations

Tirone E. David, Susan Armstrong, Joan Ivanov, Christopher M. Feindel, Ahmad Omran and Gary Webb

J Thorac Cardiovasc Surg 2001;122:39-46

- 120 patients
- Reimplantation 53%
- Remodeling 47%
- Marfan 45%
- BAV 2%
- AI 3+ 4+ 40%
- Cusp repair 11%

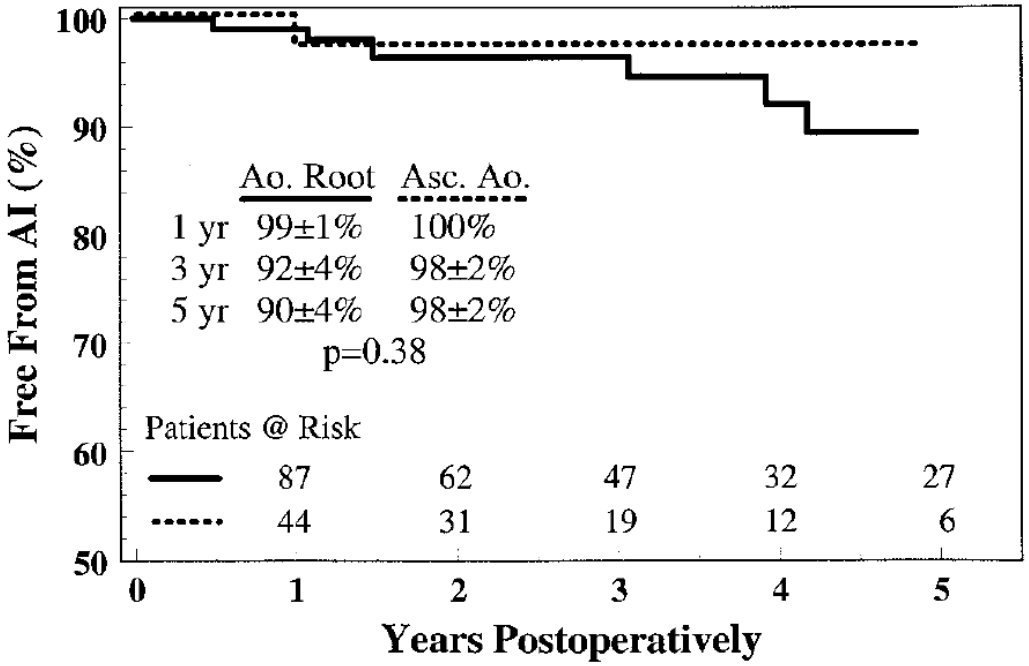
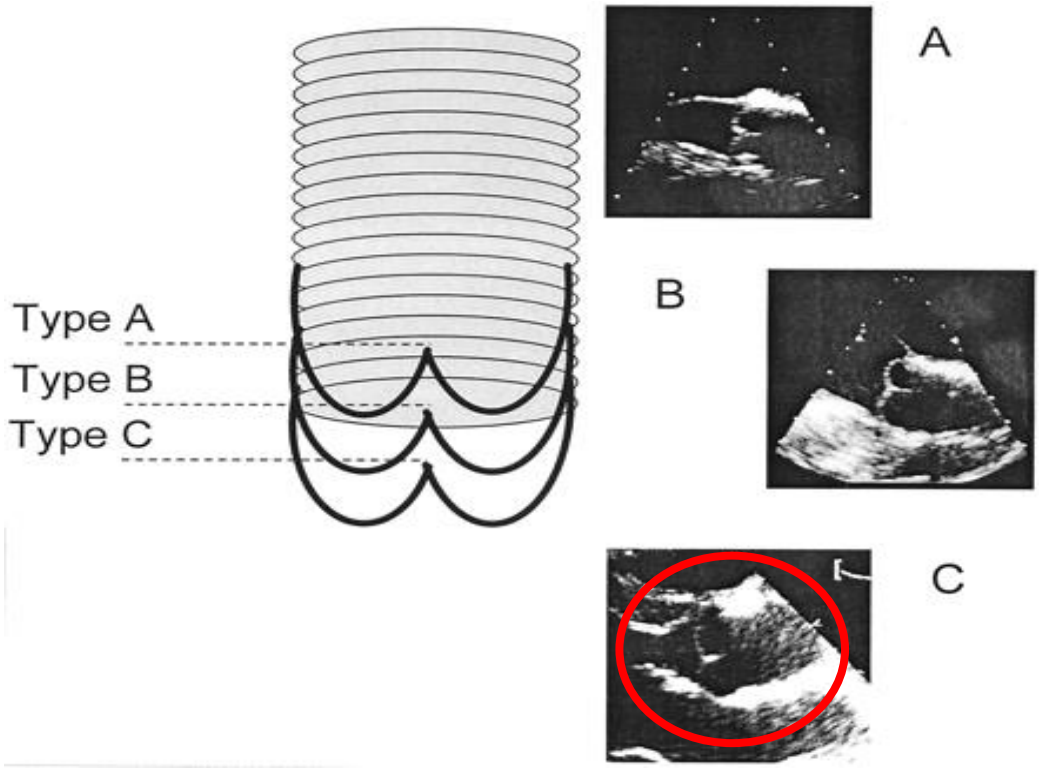
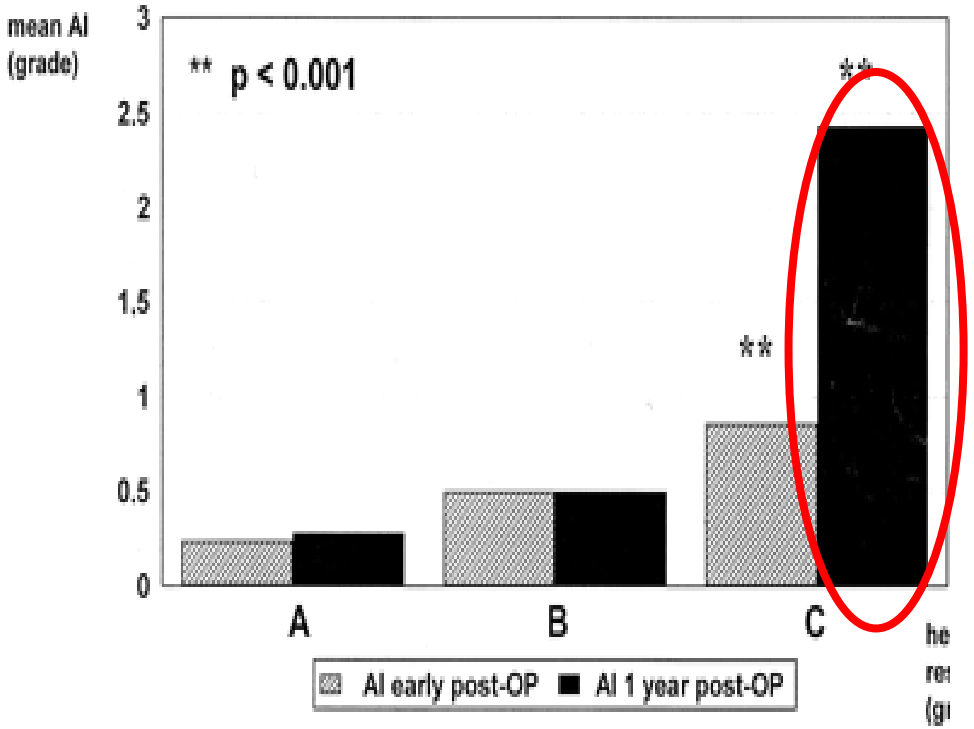


Figure 3. Freedom from 3+ or 4+ AI.

Analysis of the mechanisms of failure

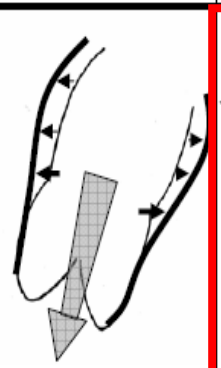
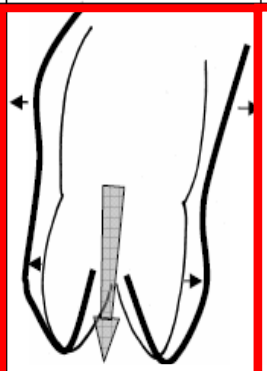
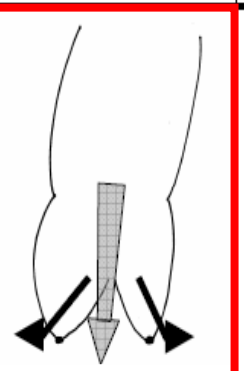
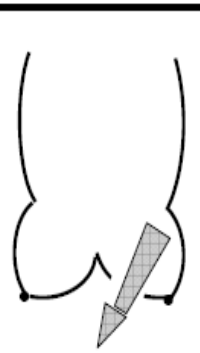
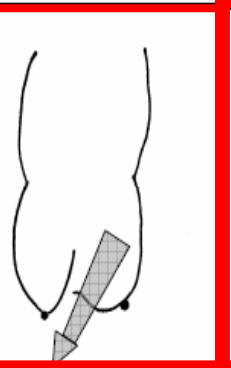
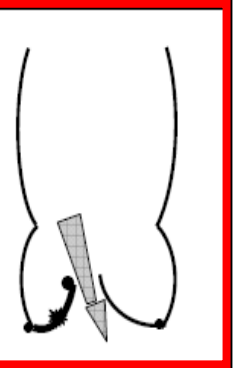




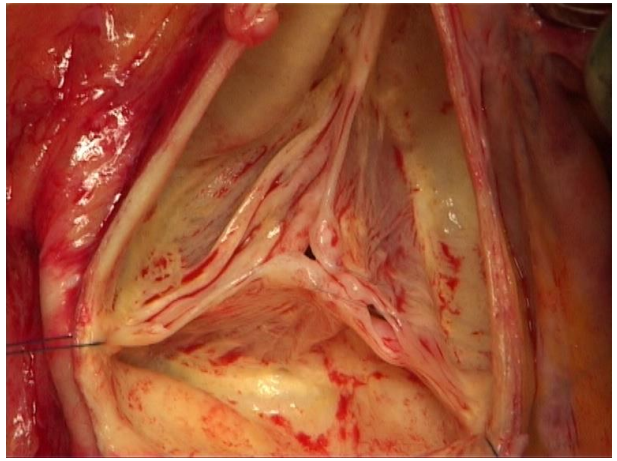
Valve sparing technique ? Need for cusp repair ?

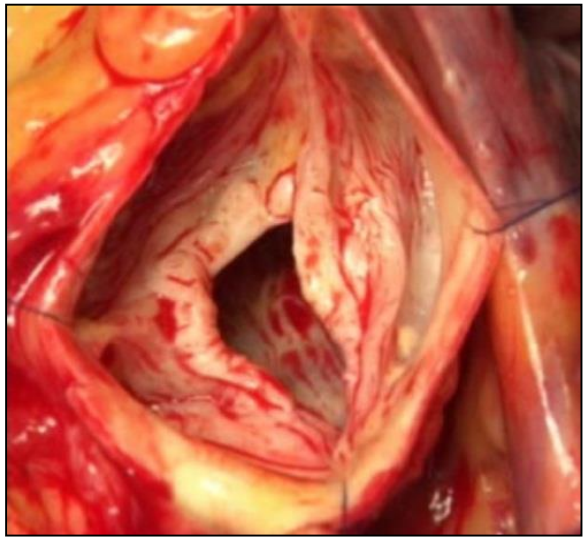
Pethig K. ATS 2002

Functional Classification of AI

AI Class	Type I: Normal cusp motion with FAA dilatation or cusp perforation				Type II: Cusp Prolapse	Type III: Cusp Restriction
	Ia	Ib	Ic	Id		
Mechanism						
Repair Techniques (Primary)	STJ remodeling *Ascending aortic graft*	Aortic Valve sparing: *Reimplantation or Remodeling with SCA*	SCA	Patch Repair *Autologous or bovine pericardium*	Prolapse Repair *Plication* *Triangular resection* *Free margin Resuspension* *Patch*	Leaflet Repair *Shaving* *Decalcification* *Patch*

+ Annuloplasty



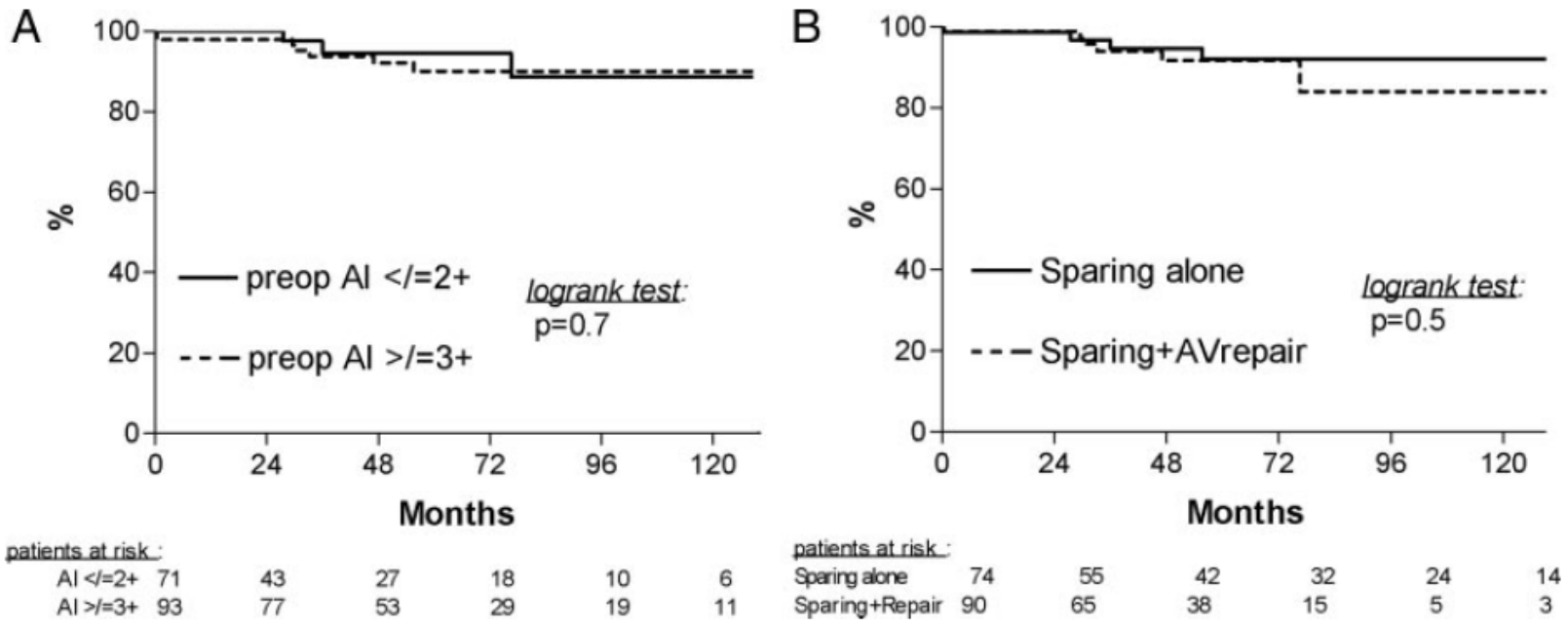


El Khoury G.
Cur. Op. Card. 2005

AI and leaflet repair in valve sparing reimplantation

Effects of Preoperative Aortic Insufficiency on Outcome After Aortic Valve–Sparing Surgery

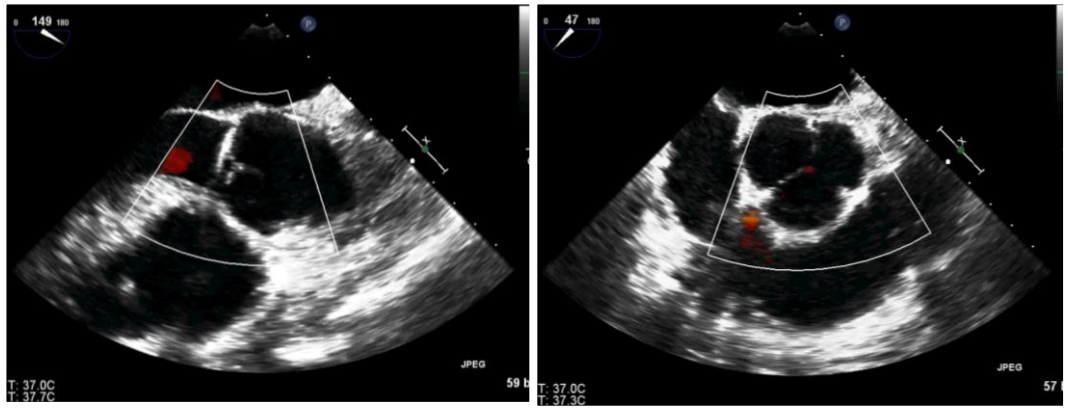
- 164 patients
- Reimplantation 75%
- Remodeling 25%
- Marfan 10%
- BAV 32%
- AI 3+ 4+ 60%
- Cusp repair 55%



L. de Kerchove Circ. 2009

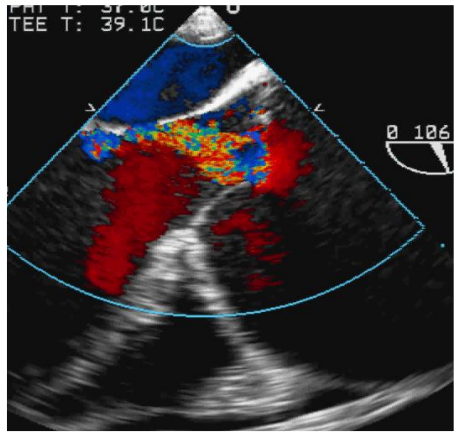
Probability of Cusp Repair in VSRR in function of preoperative AI

- No AI



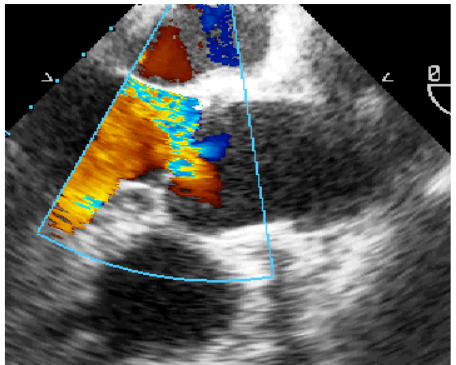
➢ Low ± 10%

- Central AI



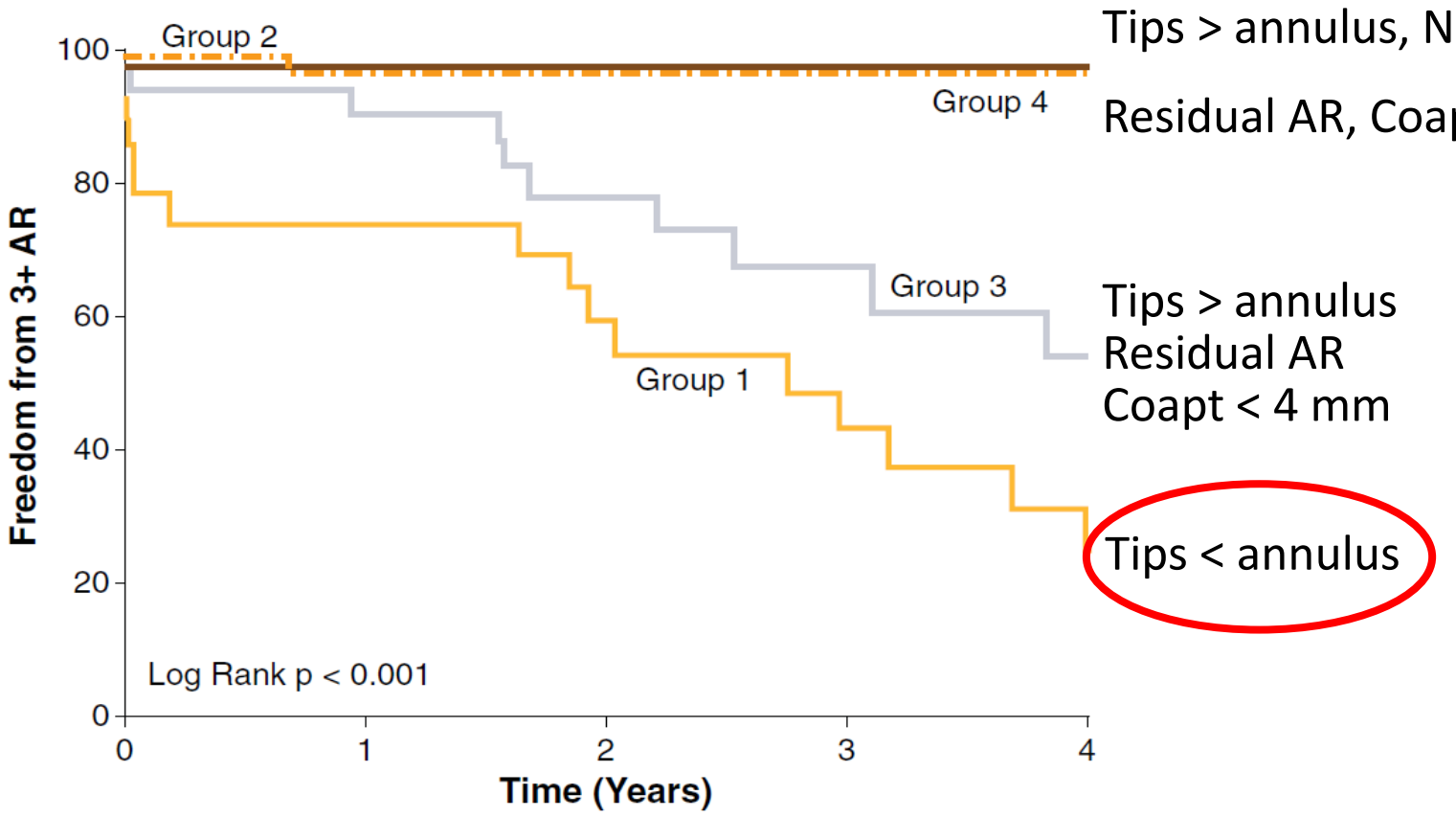
➢ Moderate ± 50%

- Eccentric AI



➢ High ± 100%

Cusp configuration in AV repair



Tips > annulus, No AR

Residual AR, Coapt >4 mm

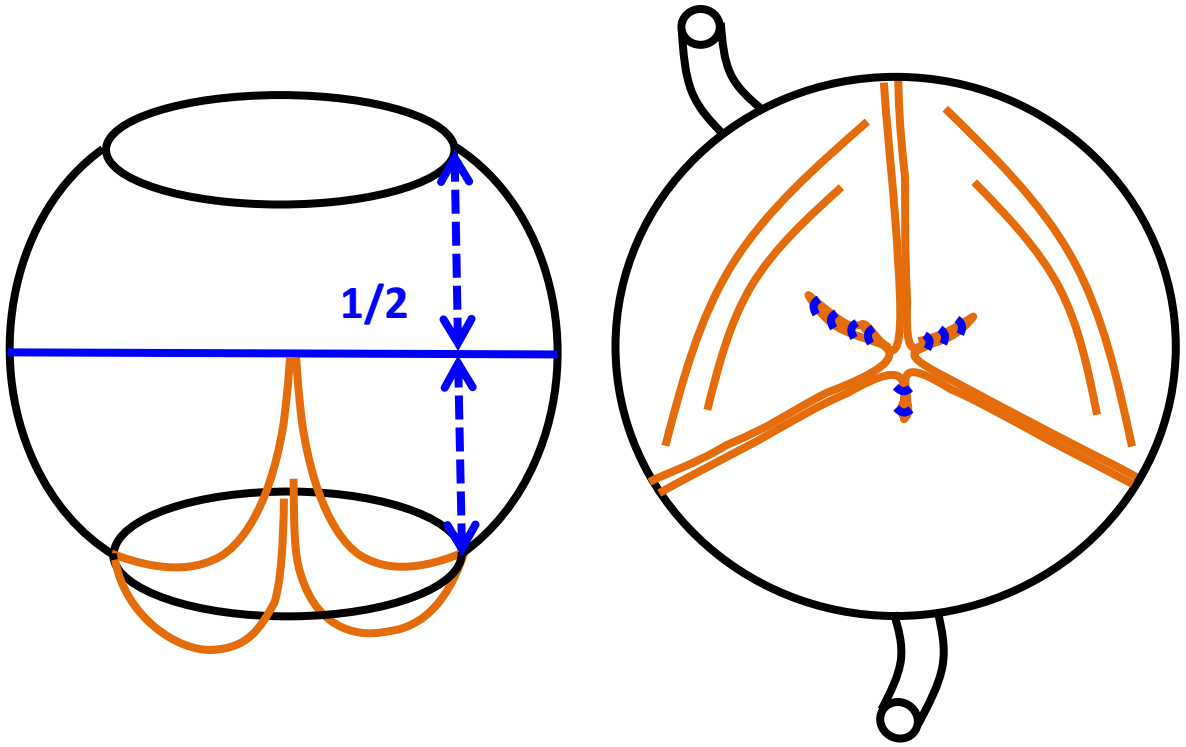
Tips > annulus
Residual AR
Coapt < 4 mm

Tips < annulus

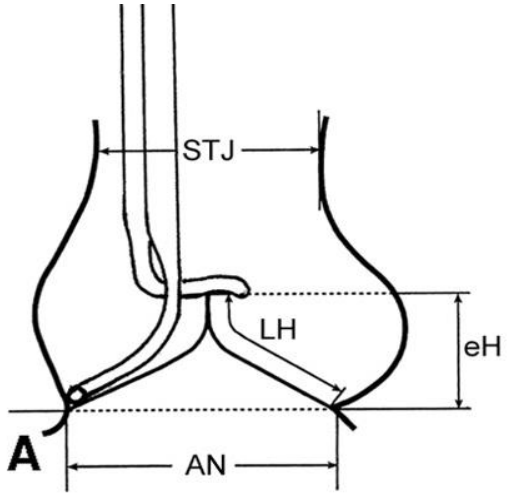
Cusp Repair is crucial to achieve good valve configuration!

le Polain JB. JACC Card. Im. 2009

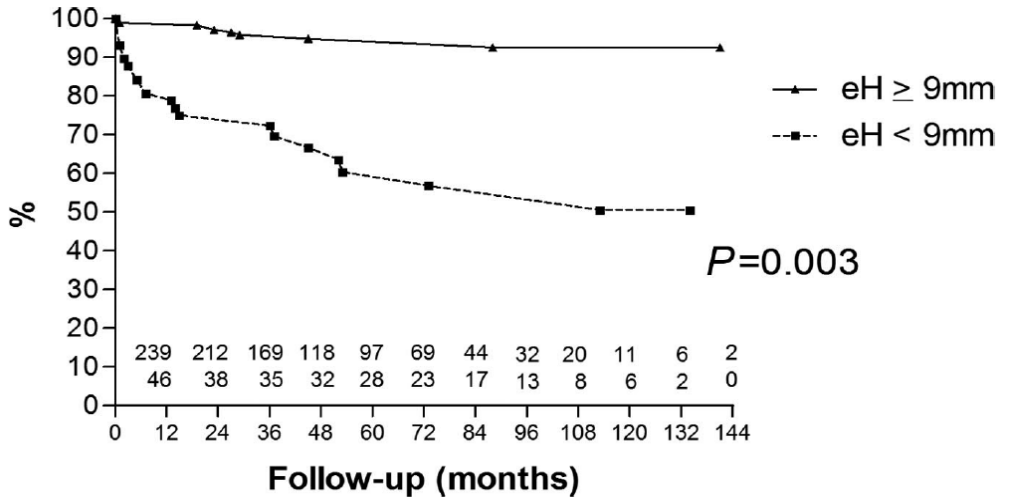
Cusp configuration in AV repair



G. El Khoury G.



Schäfers HJ. JTCVS 2006

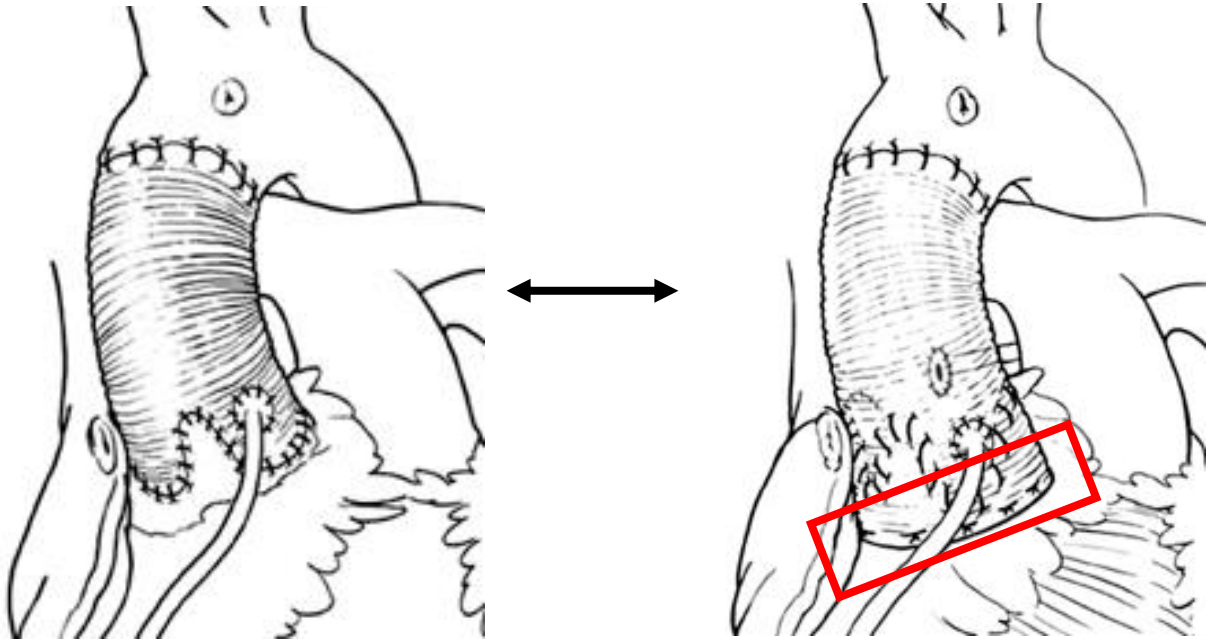


Aicher D. Circ. 2011

But AI was **NOT** the **ONLY** problem in VSRR

Remodeling

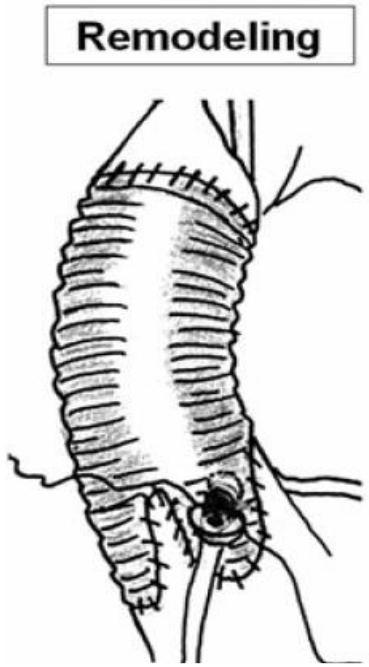
Reimplantation



- *Birks EJ., Yacoub MH. Circulation. 1999*
- *De Olievera NC., David TE. JTCVS 2003*
- *Miller DG. JTCVS 2003*
- *Bethea BT., Cameron D. ATS 2004*
- *David T. JTCVS 2006*
- *Erasmi A., Sievers HH. ATS 2007*

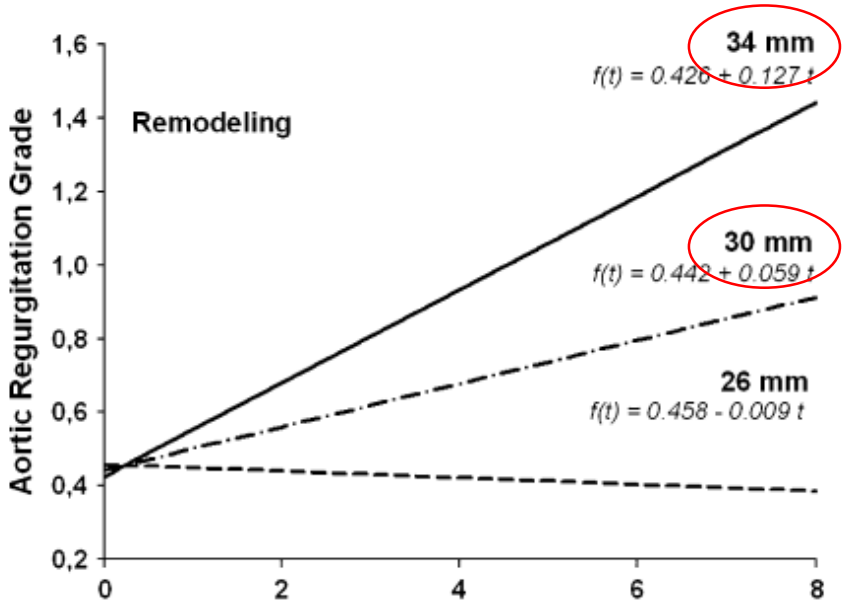
Suggest better repair durability with the Reimplantation technique

Annulus dilatation is very bad in remodeling



✓ *Hanke T., Sievers H.J. JTCVS 2009:*

- 191 VSRR, 76% TAV
- 56% Remodeling



✓ *Kunihara T., Schäfers H.J. JTCVS 2012:*

- 430 VSRR, 70% TAV,
- 93% remodeling

✓ *Schäfers H.J. JTCVS 2016:*

- 747 Remodeling, 58% TAV,

TABLE 2. Risk factors by multivariate Cox regression analysis (−2 log-likelihood function = 161.87, chi-square = 72.79, $P < .001$)

Variable	*P* value	HR	95% CI
Diameter of AV junction (mm)	<.001	1.43	1.21-1.69
Use of annuloplasty	.01	1.28	1.89-66.26
Myocardial ischemia (min)	.04	0.96	0.93-1.00
Effective height	<.001	0.58	0.43-0.79
Use of pericardial patch	<.001	6.24	2.30-16.90

AV, Aortoventricular; *CI*, confidence interval; *HR*, hazard ratio.

Relationship between chronic AI and annulus dilatation

- 127 pts with chronic AR, 74% TAV, 16% BAV

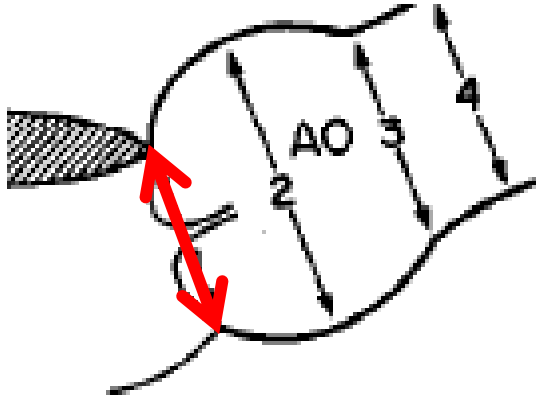
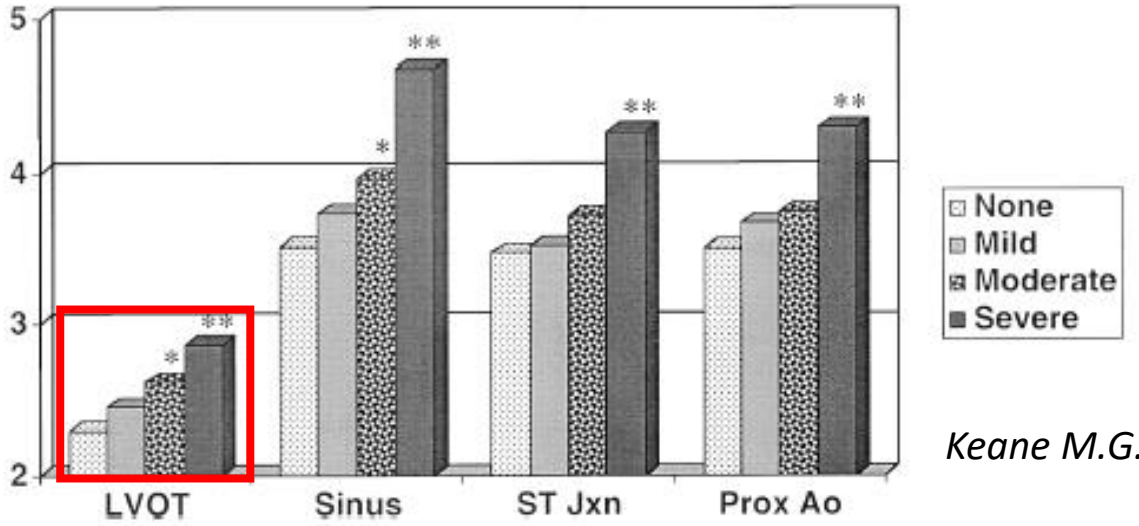


Table II. Degree of AR and aortic root size indexed by body surface area at follow-up study

	Mild AR (cm/m^2) (n = 67)	Moderate AR (cm/m^2) (n = 45)	Severe AR (cm/m^2) (n = 15)	p Value*
Aortic anulus	1.29 ± 0.23	1.38 ± 0.23	1.39 ± 0.11	0.055
Valsalva sinuses	1.89 ± 0.34	2.04 ± 0.31	2.09 ± 0.32	0.025
Supraaortic ridge	1.49 ± 0.30	1.71 ± 0.35	1.76 ± 0.43	0.001
Ascending aorta	1.97 ± 0.42	2.16 ± 0.49	2.19 ± 0.47	0.049

Padial LR. Am. Heart. J. 1997

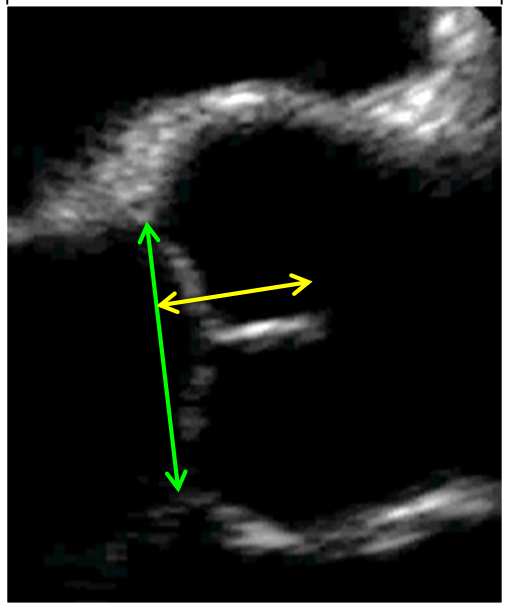
- 84 pts BAV with AR



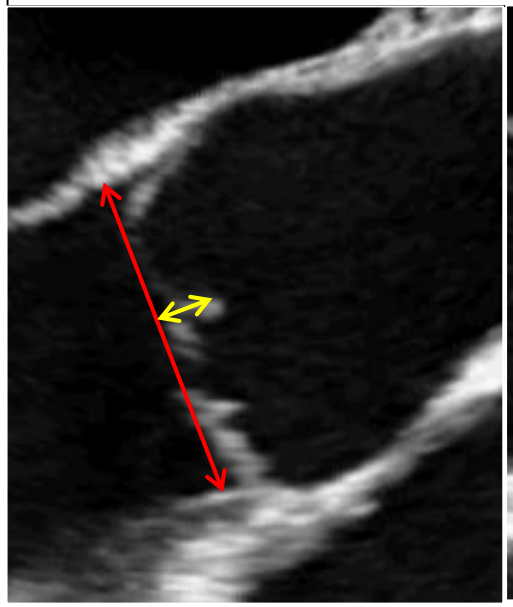
Keane M.G. Circulation. 2000

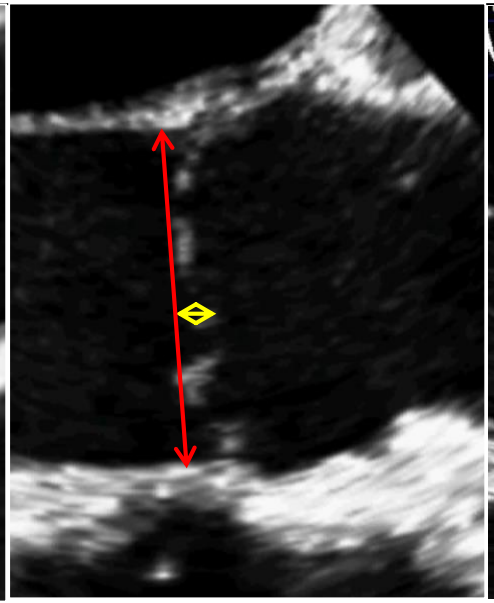
VAJ dilatation

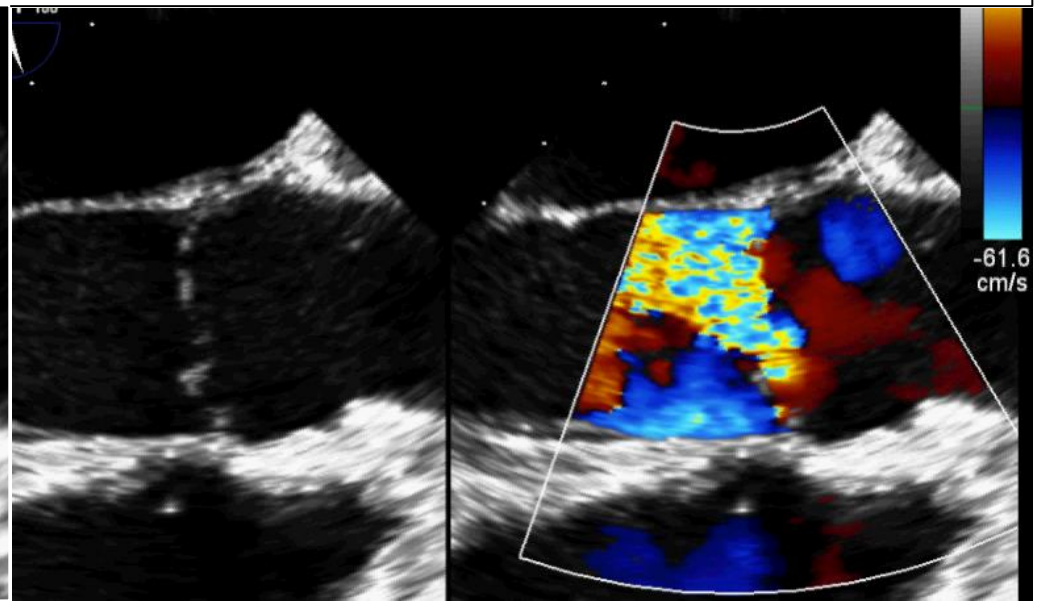
Normal VAJ



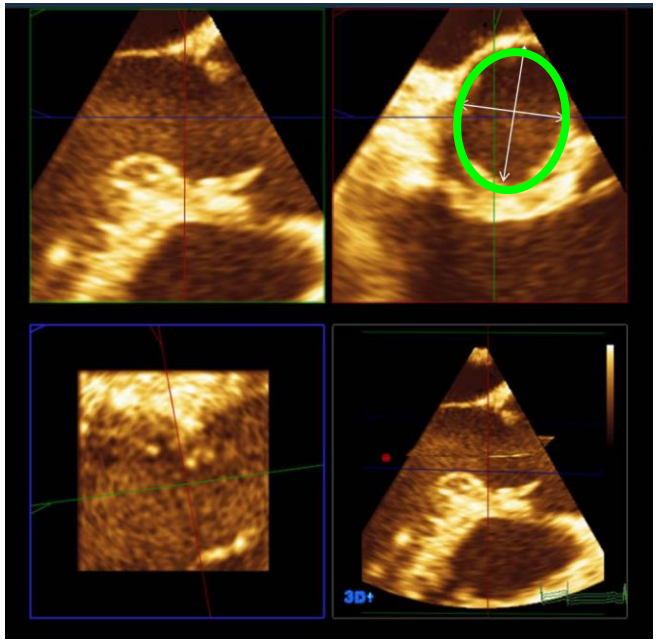
Dilated VAJ







Annulus size in normal and pathological settings



Ratio 0,8

	Normal TAV N=32	AI or aneurism TAV N=37	AI or aneurism BAV N= 27
2D echo	22.8 ± 2.4	26.1 ± 4.1$^{\&}$	30 ± 3.9$^{\&\$}$
3D small Ø	21.8 ± 2.5	25.1 ± 4.7$^{\&}$	28.1 ± 3.5$^{\&\$}$
3D long Ø	26.9 ± 2.2	27.6 ± 4.9	30.8 ± 4$^{\&\$}$
Small/long ratio	0.8 ± 0.1	0.9 ± 0.1$^{\&}$	0.9 ± 0.1$^{\&}$

* $p < 0.05$ vs normal TAV; $^{\&}$ $p < 0.001$ vs normal TAV; $^{\$}$ $p < 0.001$ vs repaired TAV

	AI or aneurism TAV		AI or aneurism BAV	
	AI ≤ 1	AI ≥ 2	AI ≤ 1	AI ≥ 2
2D echo	23.4 ± 2.5	27.2 ± 3.9*	26.6 ± 2.6*	31.3 ± 3.8$^{\$\&}$
3D small Ø	22.5 ± 3.4	26.1 ±4.5*	25.3 ± 2.4	29.2 ± 3.3$^{\$\&}$
3D long Ø	25.4 ± 3.8	28.3 ± 4.8	27.8 ± 1.7	32.1 ± 4.3$^{\$\&}$
Small/long ratio	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1

* $p < 0.05$ vs TAV without AR; $^{\$}$ $p < 0.05$ vs TAV with significant AR; $^{\&}$ $p < 0.05$ vs BAV without AR

C. Watremez, St-Luc, Brussels

VAJ size in normal and pathological settings

	AI or Ao aneurism TAV (mm)	AI or Ao aneurism BAV (mm)
Navarra E. EJCTS 2013	-	28 mm(2D echo)
de Kerchove L. EJCTS 2015	25.2mm (2D echo)	-
Lansac E. EJCTS 2016	(2/3 TAV, 1/3 BAV) 28.3 mm (Hegar dilator)	
Schäfers H.J. JTCS 2013	27.6 (2D echo) 30.2 (Hegar dilator)	29.7(2D echo) 31.8 (Hegar dilator)

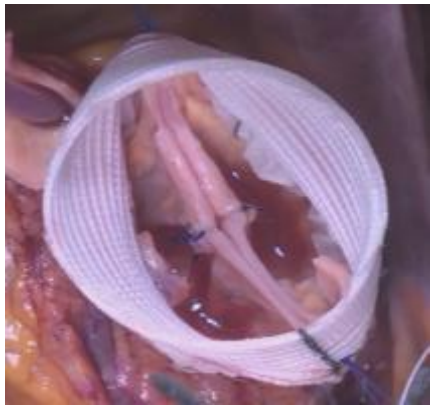
→ 2D echo measure ≈ Hegar dilator measures +2-3 mm

Role of VAJ size and annuloplasty in AV repair

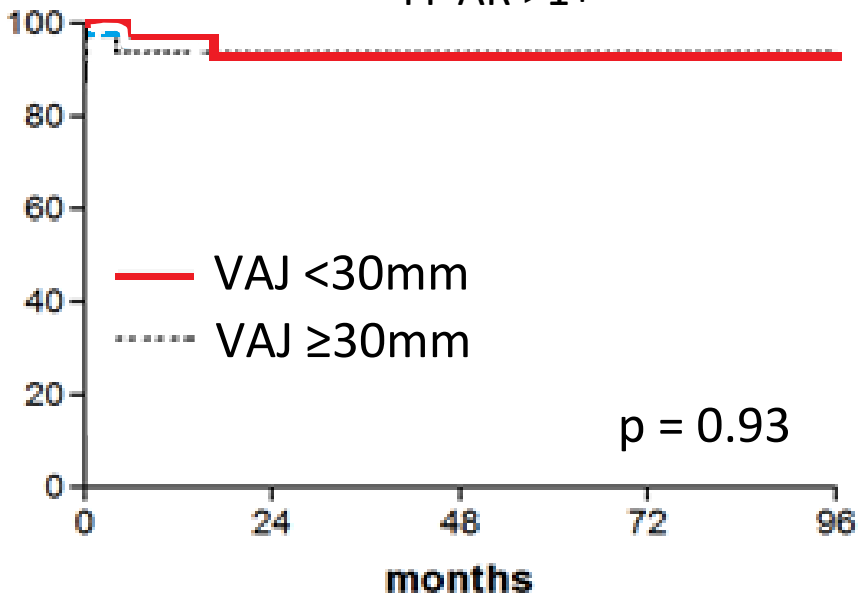
- VSR technique

BAV

(Hospit. mortality: 0%)



FF AR >1+

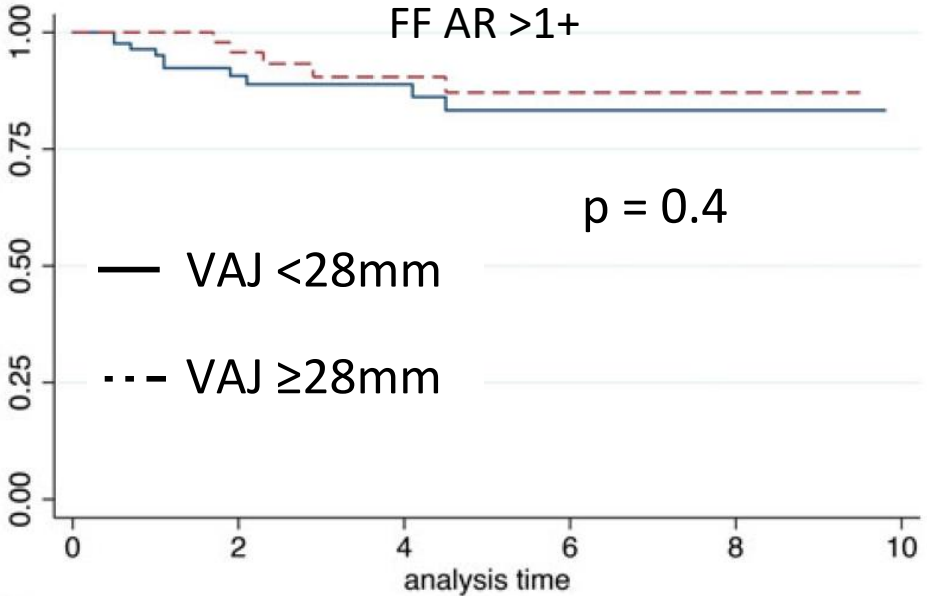


Navarra E. EJCTS 2013

TAV

(Hospit. mortality: 0.6%)

FF AR >1+



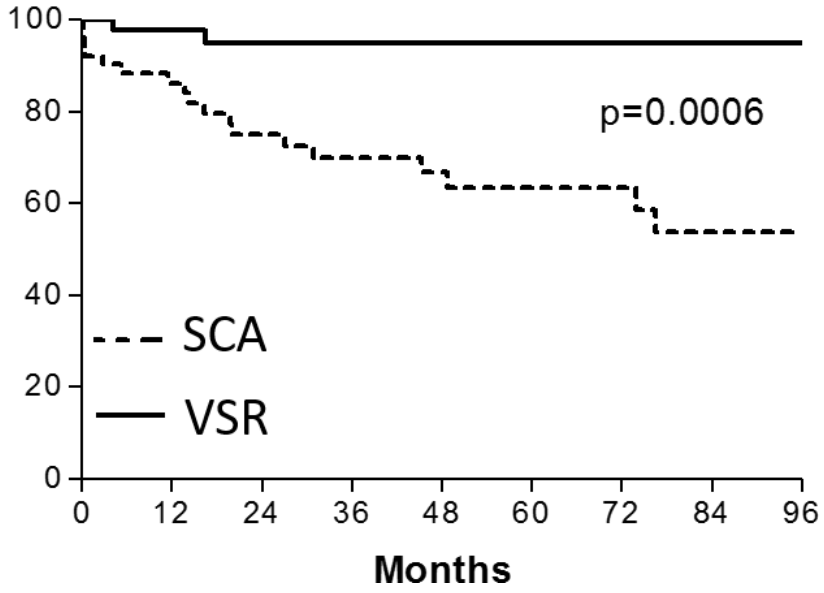
De Kerchove L. EJCTS 2015

Role of VAJ size and annuloplasty in AV repair

- SCA versus VSR technique (matched groups)

BAV

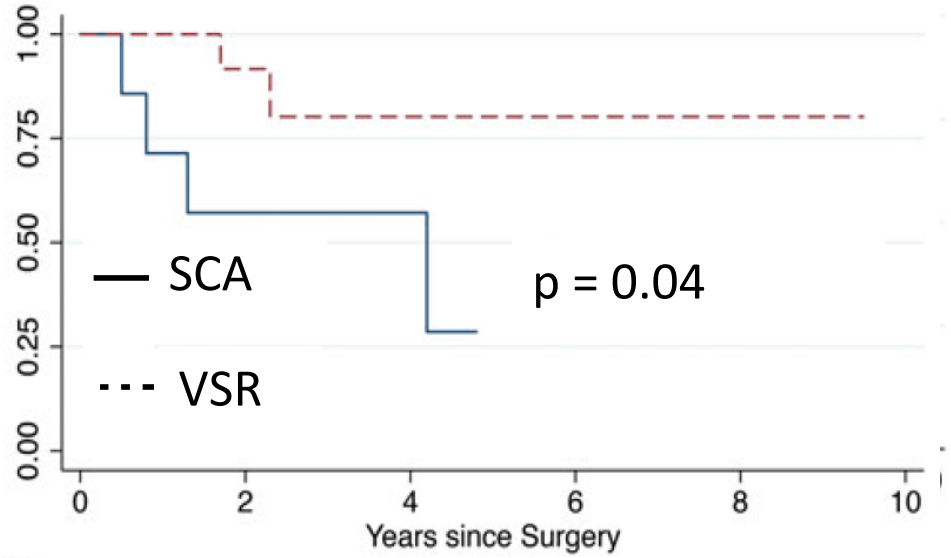
FF AR >1+



De Kerchove L. JTCS 2010

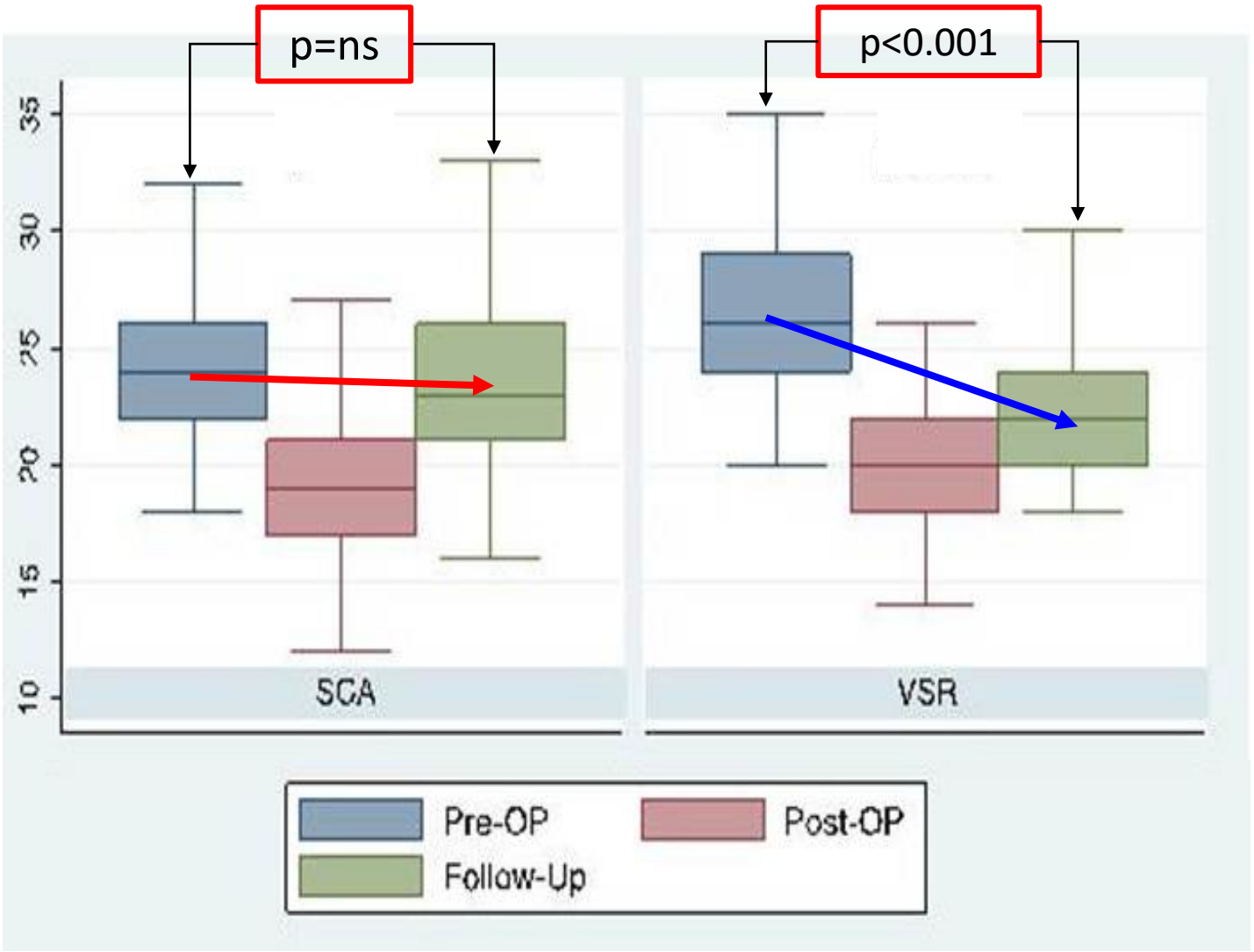
TAV

FF AR >1+



De Kerchove L. EJCTS 2015

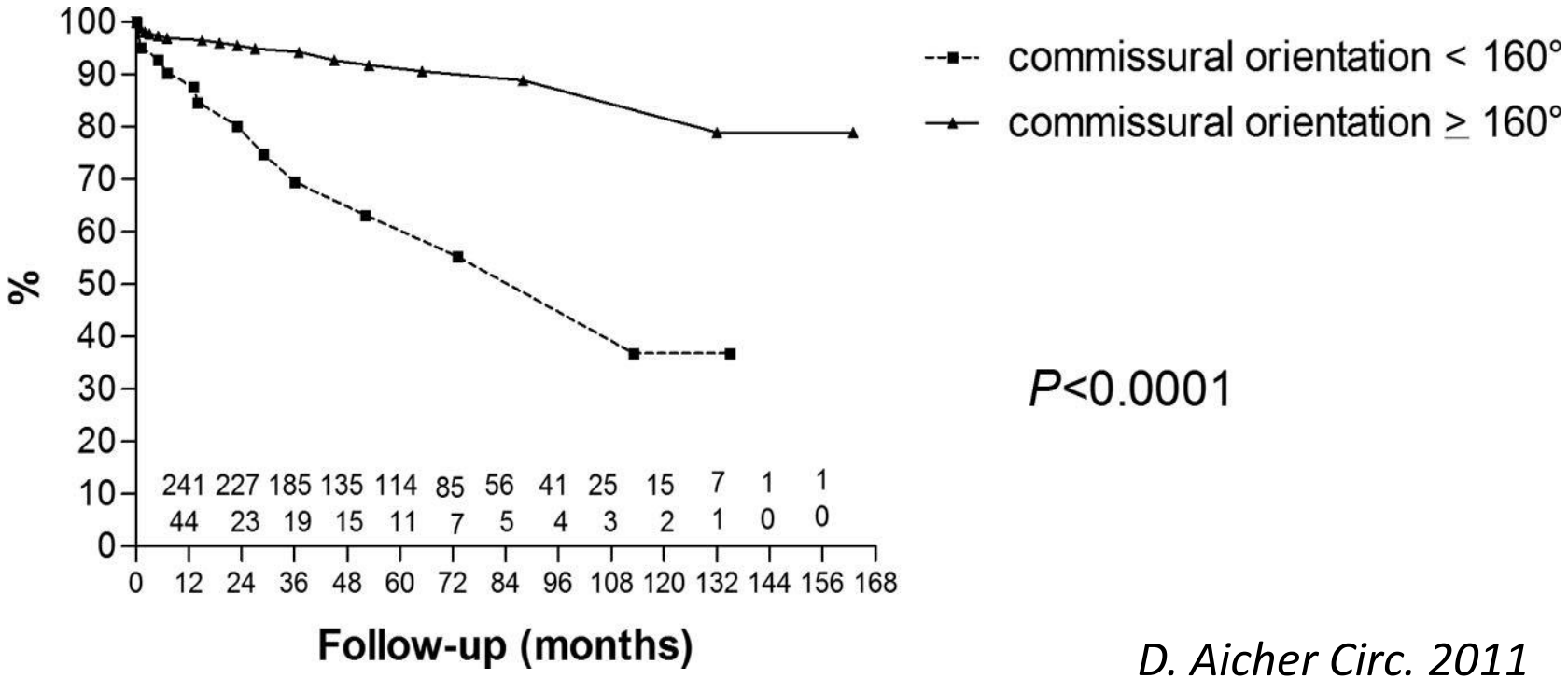
VAJ dilatation occurs in most patients with SCA in TAV repair



De Kerchove L. EJCTS 2015

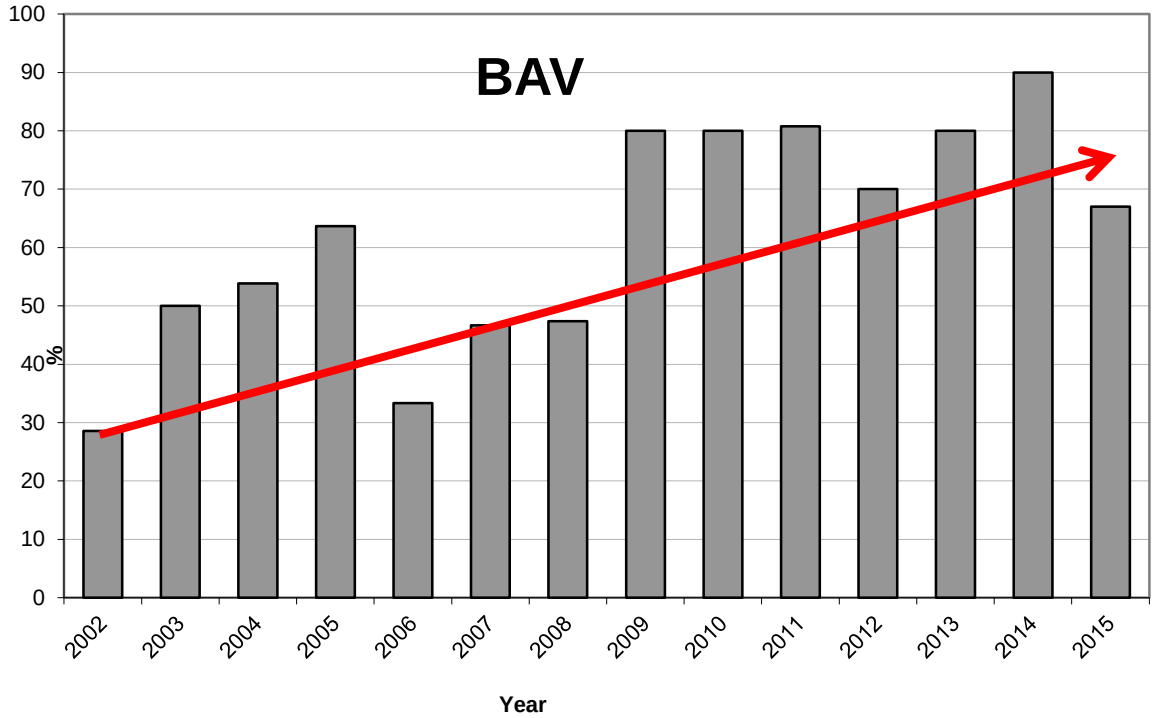
Brussels AV repair: ***Why is VSR so efficient?***

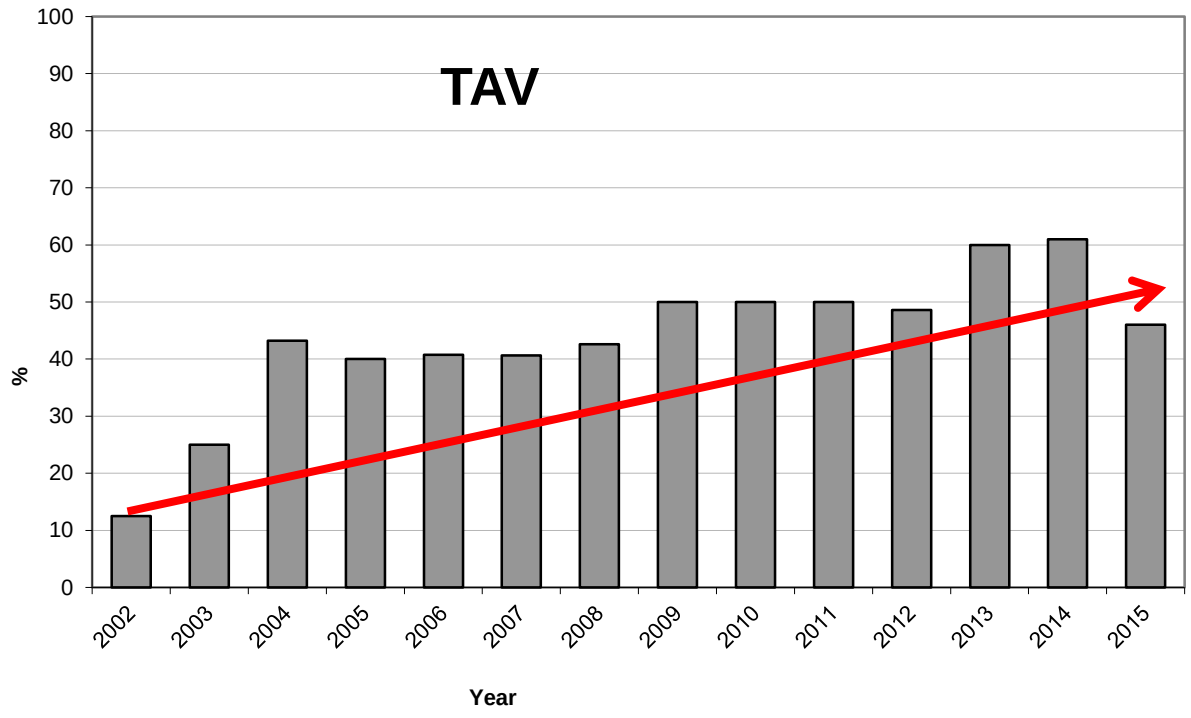
1. Circumferential prosthetic annuloplasty → **Stable over time**
2. Remodel BAV geometry to 180° → **Durable configuration**
3. Optimal Coaptation

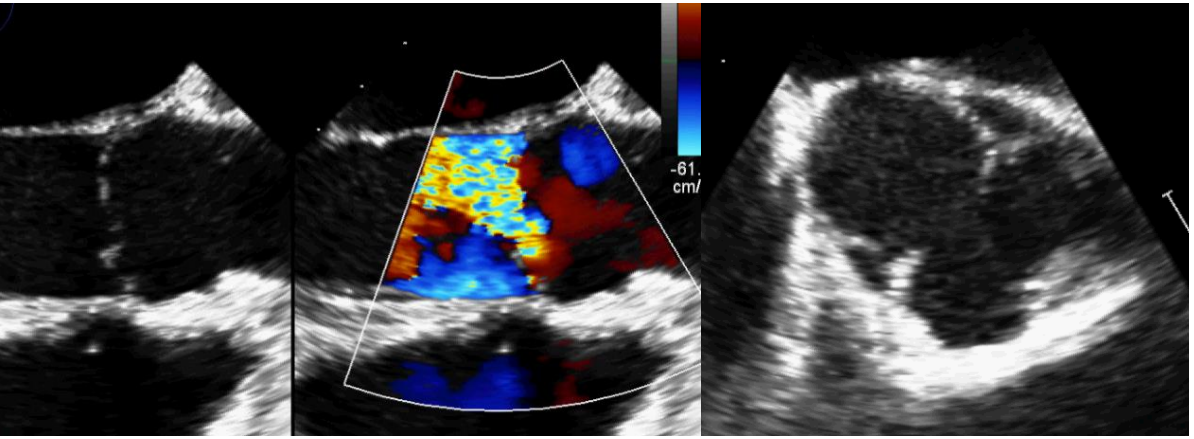


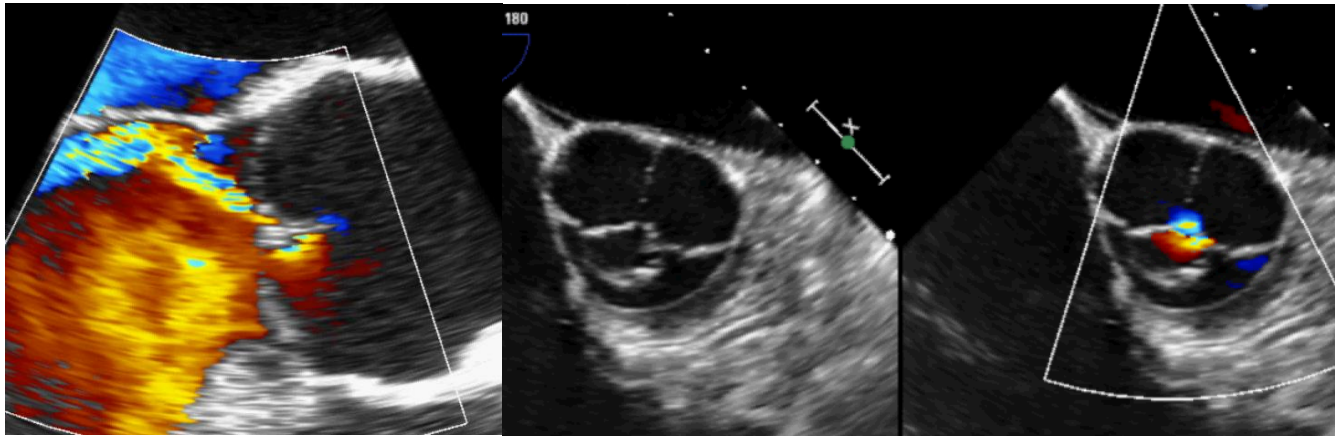
D. Aicher Circ. 2011

Rate of VS Reimplantation over year at St-Luc, Brussels









Fifteen-Year Experience with Valve Sparing – Reimplantation Technique for the treatment of aortic aneurysm and aortic regurgitation

Mastrobuoni S. MD MPH, de Kerchove L. MD PhD, Navarra E. MD, Astarci P. MD PhD, Poncelet A. MD PhD, Rubay J. MD, Noirhomme P. MD, El Khoury G. MD

Departement of Cardiothoracic and Vascular Surgery
Cliniques Universitaires St-Luc, IREC, UCL, Brussels, Belgium

Materials and Methods

- Between 1999-2017, 923 patients underwent AV repair at St. Luc's Hospital;
- **440 patients** (47.7%) were treated with VSRR and are the Study Cohort;
- Patients were divided into **3 groups** according to the indication for surgery:
  - Root aneurysm without AR (**Conventional Indication**)

    Group 1 = 139 patients (31.6%)
  - Root aneurysm with significant AR (**"debated" indication**)

    Group 2 = 212 patients (48.2%)
  - Isolated AR (**non-conventional indication**)

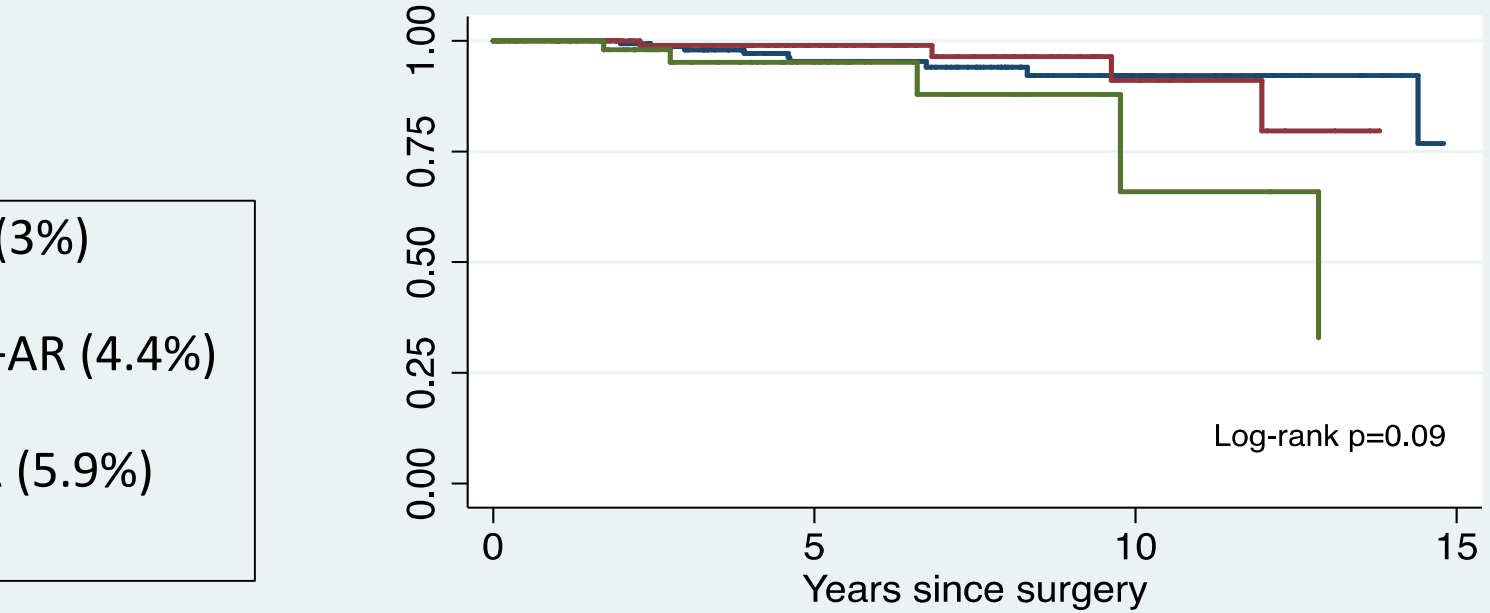
    Group 3 = 76 patients (17.3%)
  - Further 13 patients (2.7%) presented with acute type-A aortic dissection

Results: Freedom from AV reop by Group

4 in Group Aneurysm (3%)

9 in Group Aneurysm+AR (4.4%)

4 in Group isolated AR (5.9%)



Number at risk				
Group = Aneurysm + AR	204	102	33	3
Group = Aneurysm	135	58	16	2
Group = isolated AI	67	22	3	1

Group = Aneurysm + AR
Group = Aneurysm
Group = isolated AI

89.6% (95% CI: 82.2-94.0) at 10-year

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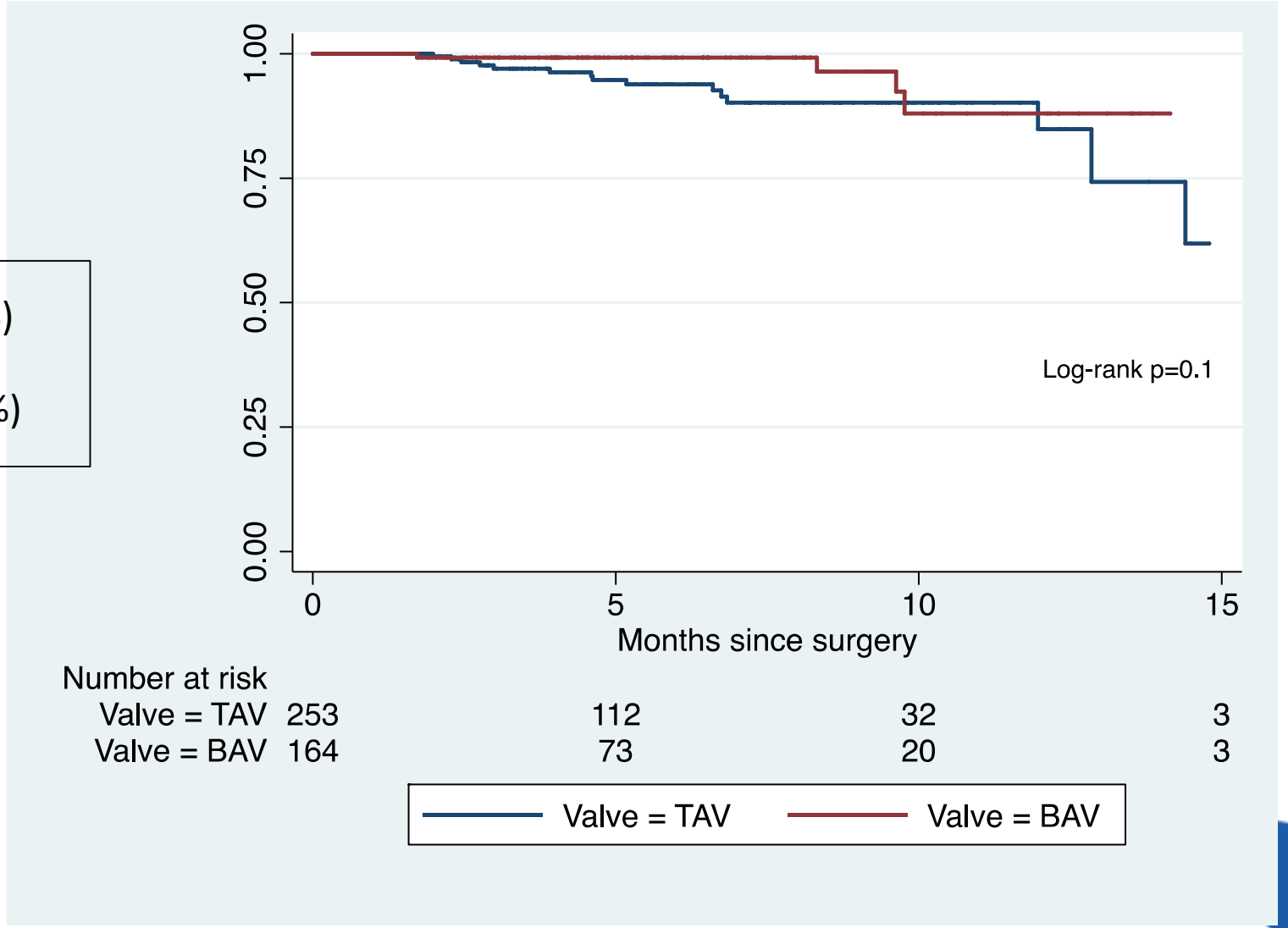
Results: Freedom from AV reop by valve phenotype

4 in BAV (2.4%)

13 in TAV (5.1%)



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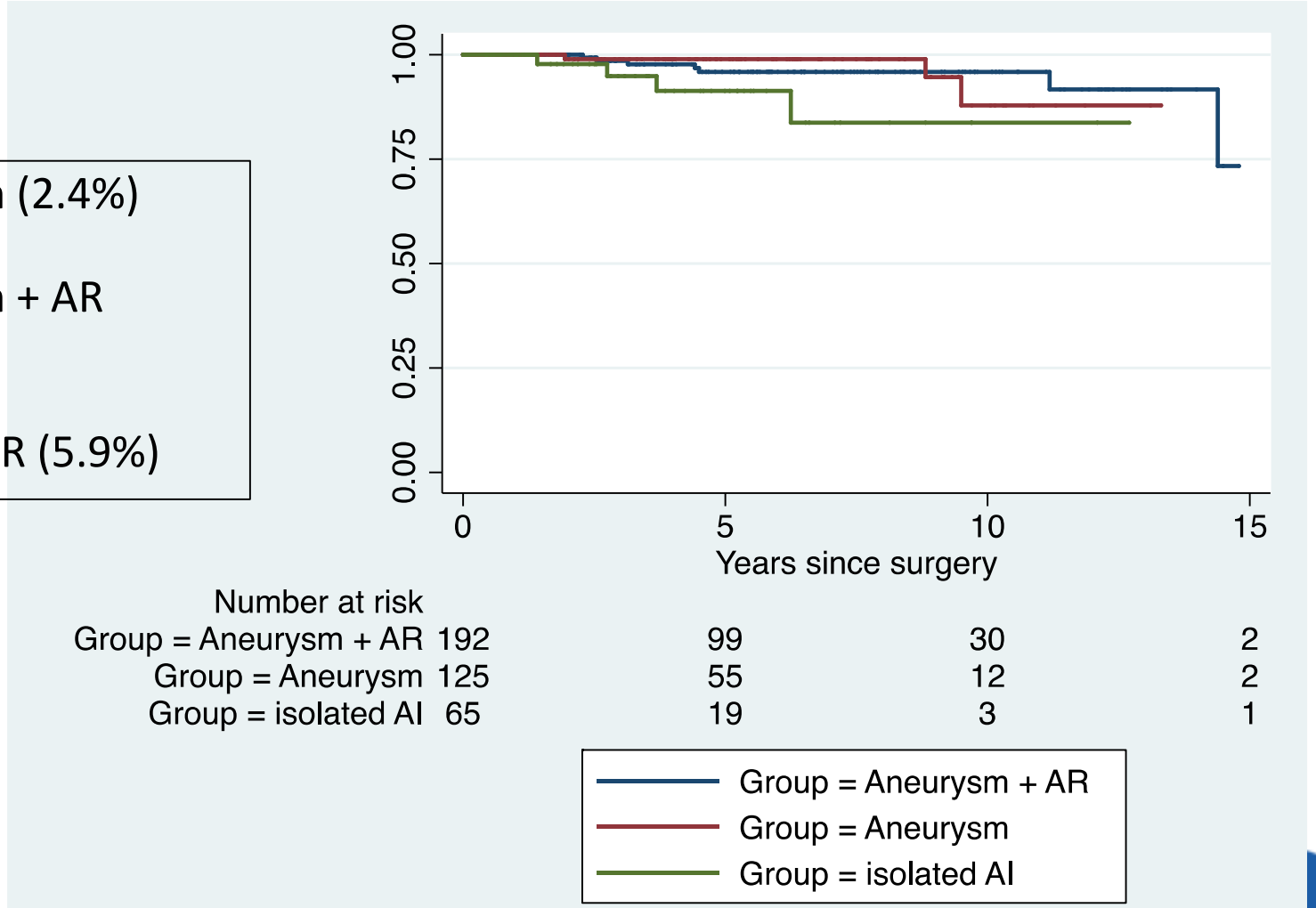
Freedom from recurrent severe AR (≥3) by Group

3 in Group Aneurysm (2.4%)

7 in Group Aneurysm + AR (3.6%)

4 in Group isolated AR (5.9%)



91.9% (95% CI: 84.9-95.7) at 10-year

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Brussels approach of root repair in regurgitant BAV

Normal Root (<40 mm)

Dilated Root (>40mm)

VAJ <28 mm

VAJ ≥28 mm

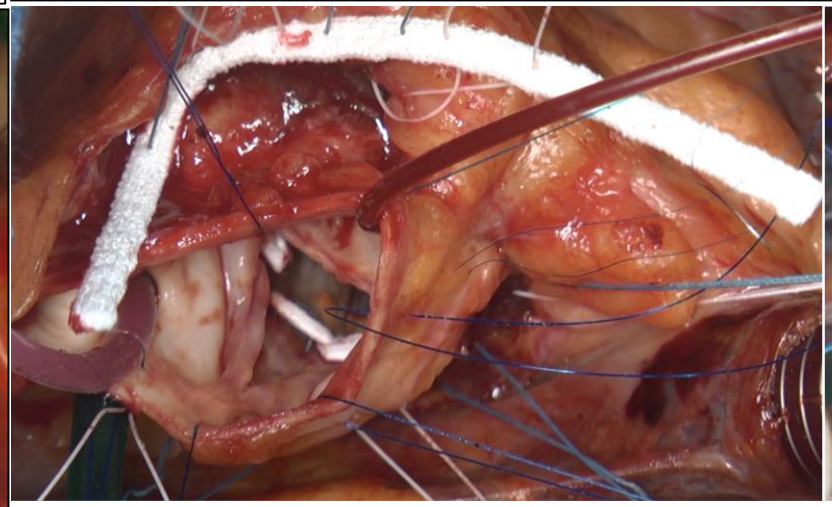
Reshape BAV geometry → 180°

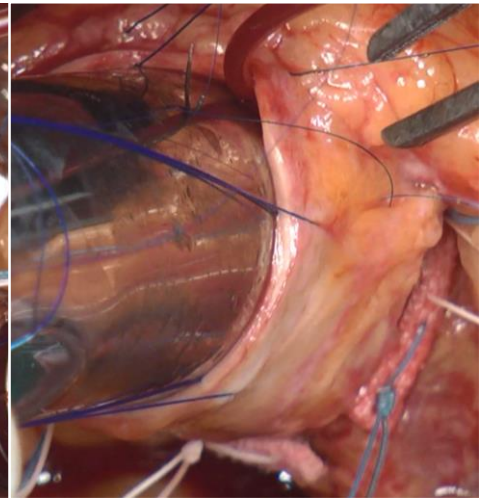
Subcom. annuloplasty

External Ring Annuloplasty

VS Reimplantion

- small VAJ/cusp
- Endocarditis
- Old patient
- VAJ 26-27





Thank you

Indications for VAJ annuloplasty

Aortic valve repair for AI

Normal Root (<45 mm)

Dilated Root (≥45 mm)

Normal VAJ (<26 mm)

Large VAJ (>26 mm)

- Large VAJ (> 28 mm)
- Root wall disease, +>40 mm
- Modify valve geometry (BAV)

(>26 mm)

(<26 mm)

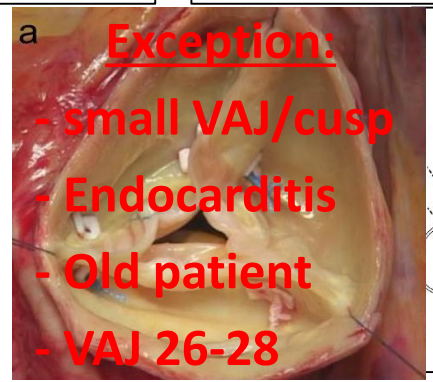
No Annuloplasty

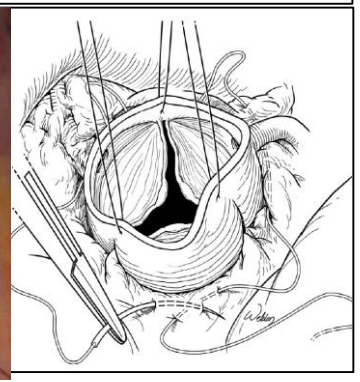
Ring annuloplasty

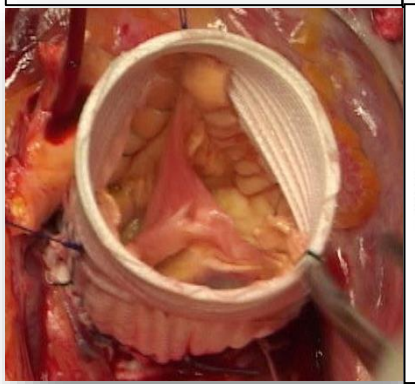
Reimplantation

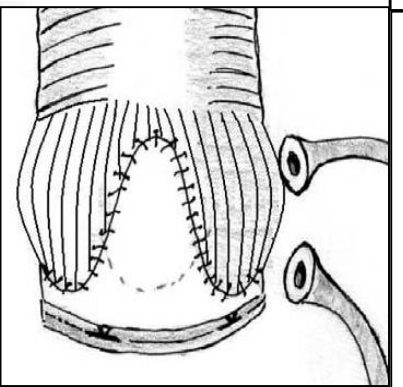
Remod.+ Anpl

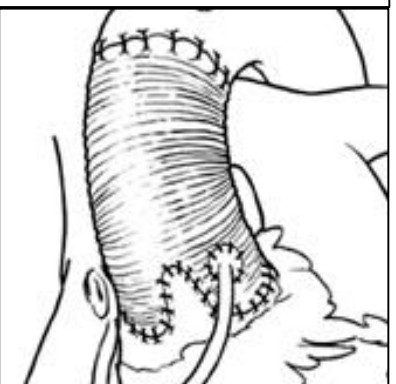
Remodeling











Demographics

	Aneurysm n=139	Aneurysm + AR n=212	Isolated AR n=76	*p*
Mean age ± SD (years)	47±14	51±15	42±13	0.05
Male, n (%)	128 (92.1)	191 (90.1)	70 (92.1)	0.7
Bicuspid AV, n (%)	49 (35.2)	76 (55.9)	52 (68.4)	<0.001
Grade of Aortic regurgitation, n (%) 0-1 2 3 4	139 (100)	0 70 (33.0) 103 (48.6) 39 (18.4)	0 6 (7.9) 58 (76.3) 12 (15.8)	<0.001
NYHA Functional Class (%): I II III IV	112 (80.6) 23 (16.5) 3 (2.2) 1 (0.7)	105 (93.7) 79 (37.3) 28 (13.2) 0	41 (53.9) 30 (39.5) 5 (6.6) 0	<0.001
LV Ejection Fraction ≥50% 31-49 ≤30	 132 (95) 7 (5) 0	 175 (82.5) 33 (15.6) 4 (1.9)	 69 (90.8) 7 (9.2) 0	0.03
LVEDD (mm), mean ± SD	53±5	61±8	63±7	0.02
VAJ (mm), mean ± SD	27 ± 3*	28 ± 4	29 ± 4*	0.007*
Previous Ross operation, n (%)	3 (2.1)	4 (1.9)	5 (6.6)	0.09
Connective Tissue Disorder, n (%)	19 (13.7)	14 (6.6)	1 (1.3)	0.004

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Results: intra- and post-op data

	Aneurysm n=139	Aneurysm + AR n=212	Isolated AR n=76	*p*
Graft size mm, median	30	30	30	0.3
CPB Time (min) mean ± SD)	145±35	150±34	151±26	0.6
Concomitant Procedures, n(%): Mitral Valve Repair Hemi-arch CABG	37 (26.6) 5 (5.0) 4 (2.9) 18 (0.7)	54 (25.5) 13 (6.1) 12 (5.6) 9 (4.2)	13 (17.1) 6 (7.9) 0 4 (5.2)	0.2
Cusp Repair Patch	76 (54.7) 1 (0.7)	170 (80.2) 15 (7.1)	74 (97.4) 4 (5.2)	<0.001 0.02
Re-exploration fro bleeding, n (%)	21 (15.1)	23 (10.9)	8 (10.5)	0.4
Permanent Pacemaker Insertion, n (%)	9 (6.5)	7 (3.3)	5 (6.6)	0.3
30-days death	1 (0.7)	0	0	0.3
Lost to Follow-up, n(%)	4 (2.9)	8 (3.8)	10 (13.1)	0.002
Follow-up years, Median (IQR)	4.7 (2-8.5)	5.5 (2.2-9.7)	3.5 (1.7-5.8)	

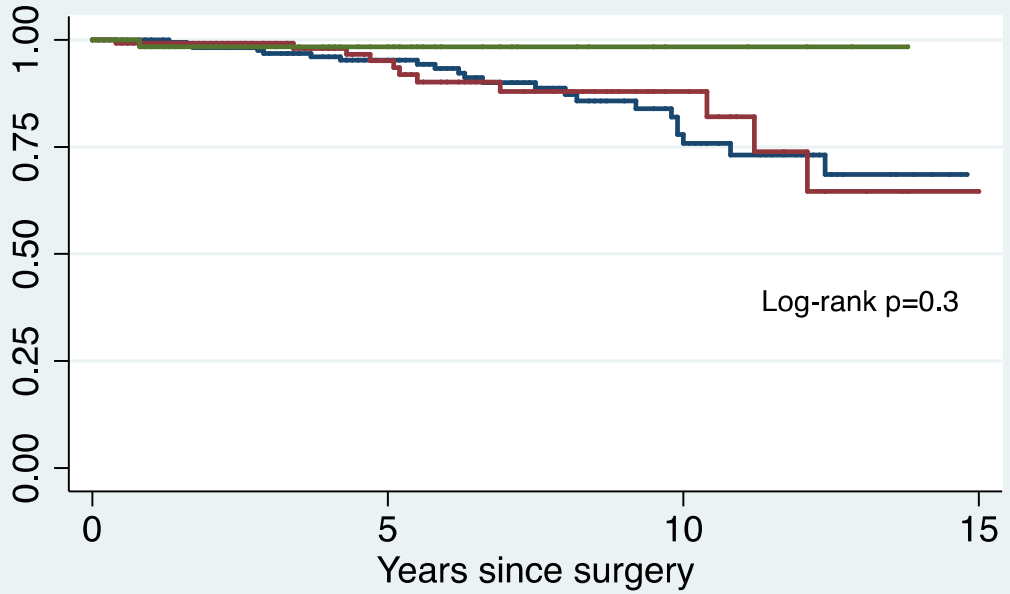
Results: Long-term survival by Group

34 late deaths (10 cardiac related)

22 in Group Aneurysm (16.5%)

11 in Group Aneurysm + AR (5.8%)

1 in Group isolated AR (1.5%)



Number at risk				
Group = Aneurysm + AR	206	108	38	4
Group = Aneurysm	133	59	18	3
Group = isolated AI	68	24	5	1

Group = Aneurysm + AR
Group = Aneurysm
Group = isolated AI

Mortality rate: 1.5% patient-year [Bentall: 2.02%]

Alive: 81.3% (95% CI: 72.9-87.3) at 10-year

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