Reconstruction of the Aortic Valve and Root: A practical approach

Annuloplasty - the evidence

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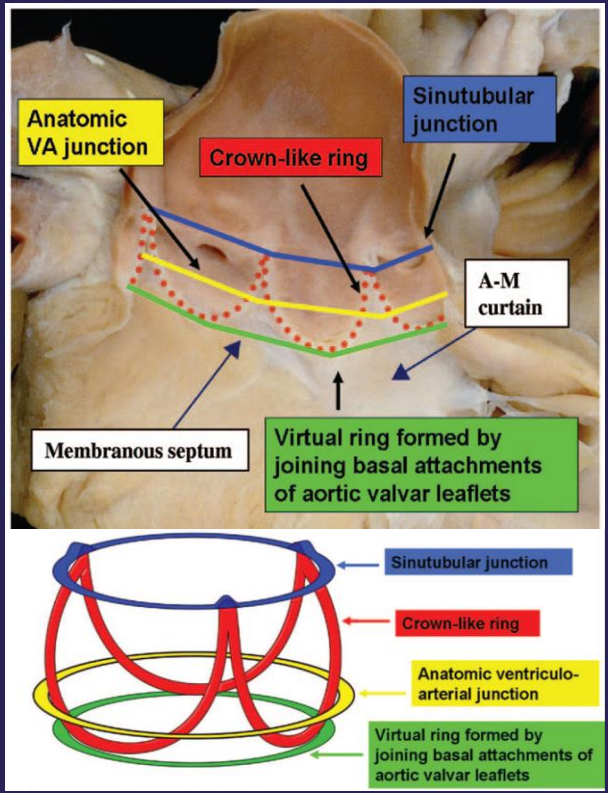
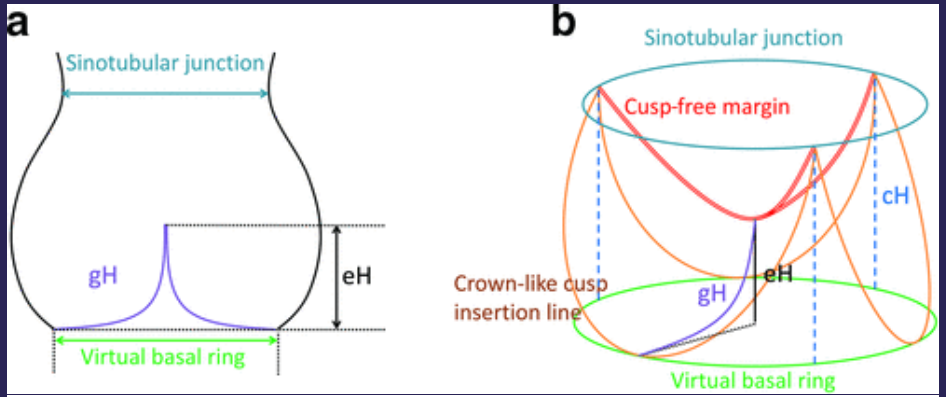
European Hospital

Aortic root and valve (functional anatomy)





From: Schäfers HJ. The 10 Commandments for Aortic Valve Repair. Innovations (Phila). 2019 Jun;14(3):188-198.

Annulus Ø: 20.5-24.5 mm

Aortic valve surgery

Goal for aortic valve repair

- Treatment of the dilated diameters
- Preserve root dynamics
- Restore cusp effective height

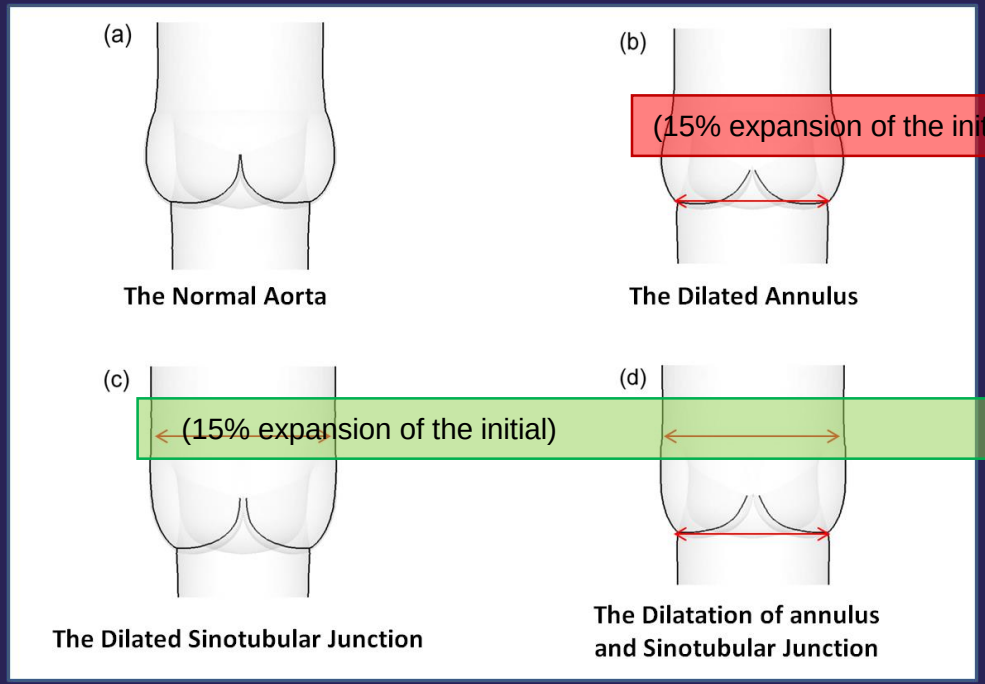
Re-establishing a normal annular diameter is the basis for a successfull repair

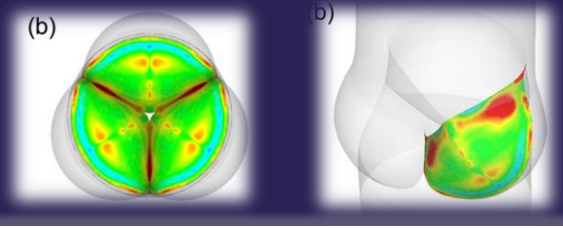
- It prevents stress on leaflets
- It maintains normal leaflet effective height
- It guarantee correct leaflet coaptation

Interactive CardioVascular and Thoracic Surgery 17 (2013) 8–12
doi:10.1093/icvts/ivt116 Advance Access publication 27 March 2013

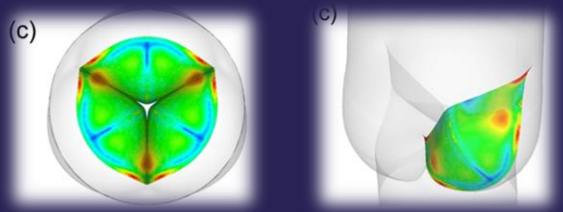
Annular dilatation and loss of sino-tubular junction in aneurysmatic aorta: implications on leaflet quality at the time of surgery. A finite element study†

Luca Weltert[a,*], Marco D. de Tullio[b], Luciano Afferrante[b], Andrea Salica[a], Raffaele Scaffa[a], Daniele Maselli[a], Roberto Verzicco[c] and Ruggero De Paulis[a]





Stress on leaflet in isolated annular ectasia + 67%



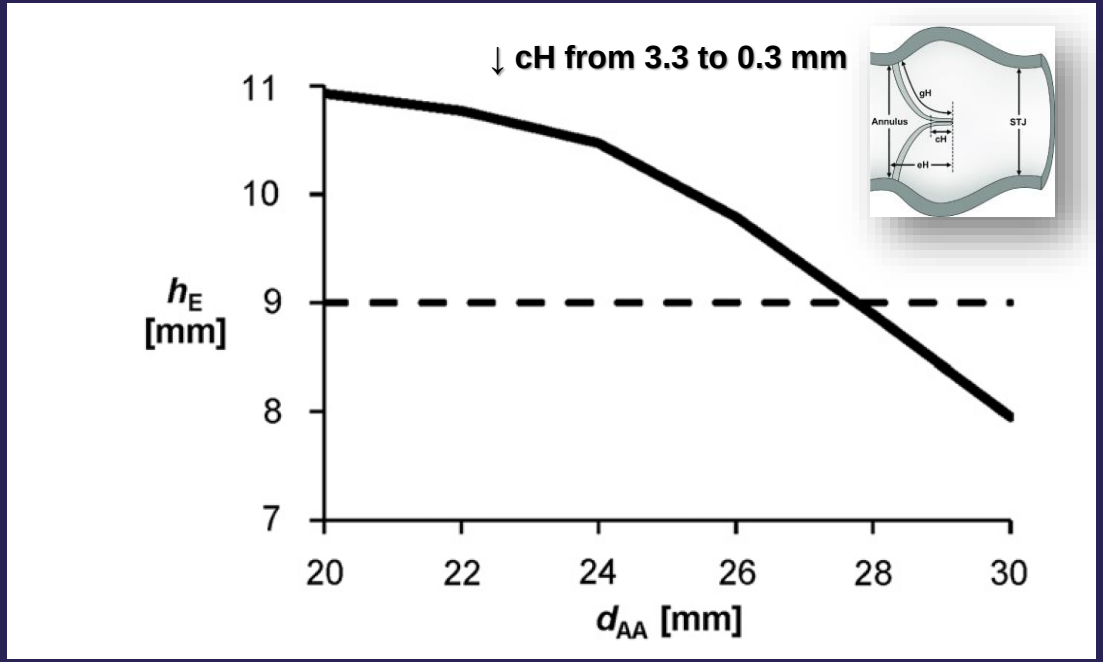
Stress on leaflet in isolated loss of ST junction + 14%

Aortic root numeric model: Annulus diameter prediction of effective height and coaptation in post–aortic valve repair

Gil Marom, MSc,[a] Rami Haj-Ali, PhD,[a] Moshe Rosenfeld, DSc,[a] Hans Joachim Schäfers, MD,[b] and Ehud Raanani, MD[c]

Normal
cH= 4-5 mm
eH= >9 mm

eH showed a strong correlation with annulus, sinus and ST junction diameter

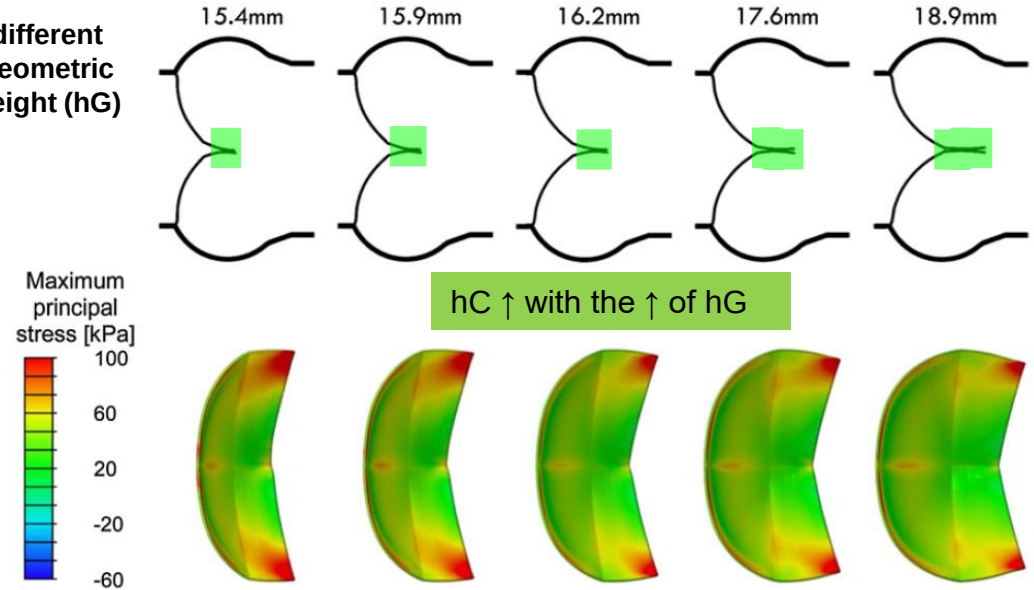


The Journal of Thoracic and Cardiovascular Surgery • January 2013

Aortic root numeric model: Correlation between intraoperative effective height and diastolic coaptation

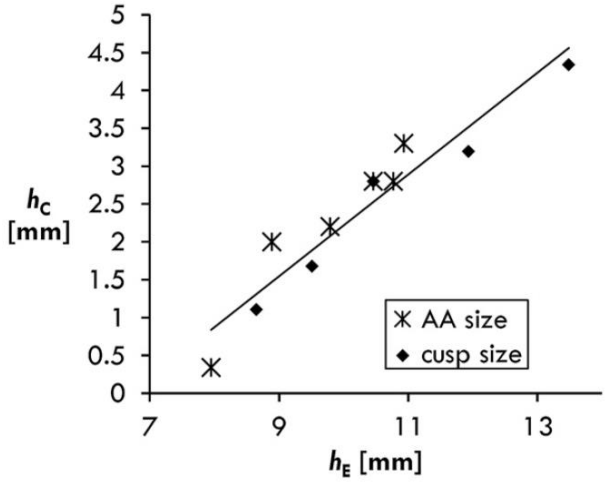
Gil Marom, MSc,[a] Rami Haj-Ali, PhD,[a] Moshe Rosenfeld, DSc,[a] Hans Joachim Schäfers, MD,[b] and Ehud Raanani, MD,[c] Tel Aviv and Tel Hashomer, Israel; and Homburg, Germany

different geometric height (hG)



hC ↑ with the ↑ of hG

linear correlation between the average hC and hE



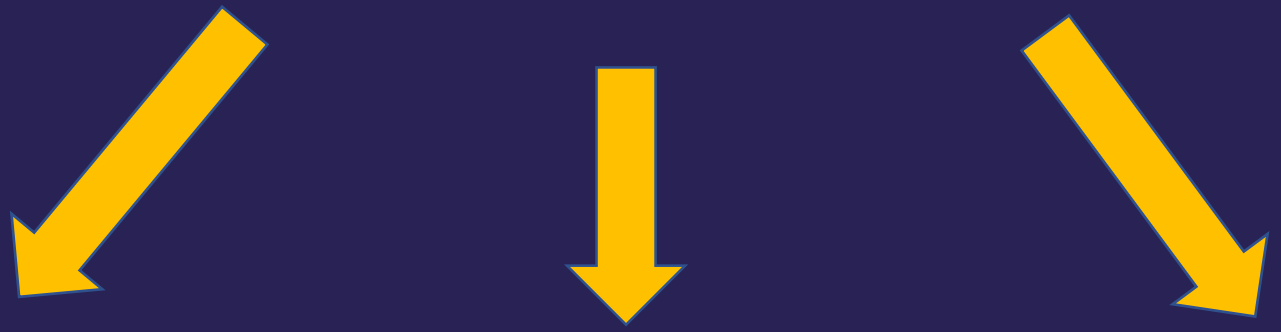
eh can be increased only by cusp intervention?

Aortic valve sparing

In many cases alteration of the root geometry is the basis for leaflet degenerative changes and cusp prolapse

Cusps abnormalities were caused by increased mechanical stresses resulting from dilatation of the STJ and/or aortic annulus

Analysis by categories



TAV

TAV in CTD

BAV

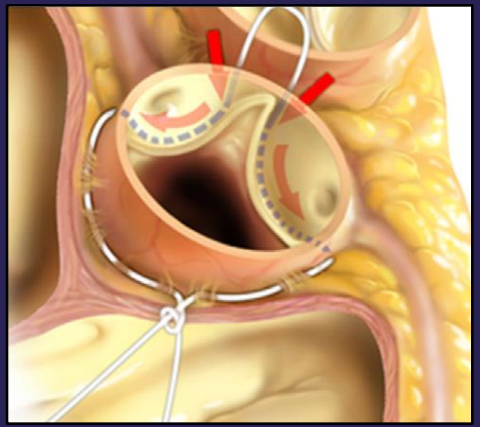
Analysis by categories

Dilated annulus

Non dilated annulus

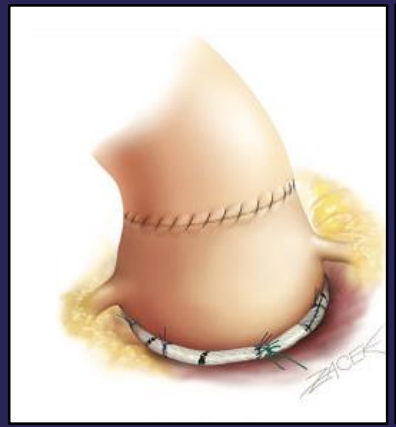
Different annuloplasty techniques

SUTURE ANNULOPLASTY



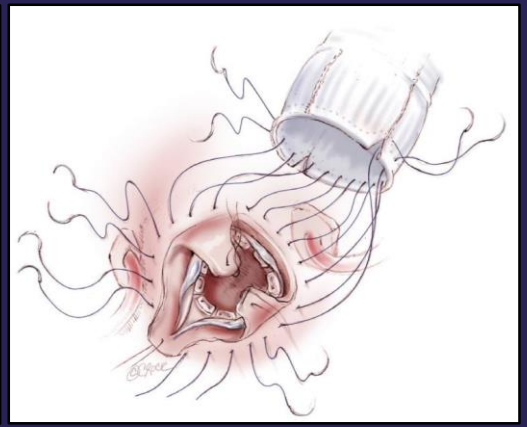
Erlich T et al. *Prog Cardiovasc Dis.* 63 (2020) 457–464.

EXTERNAL ANNULOPLASTY



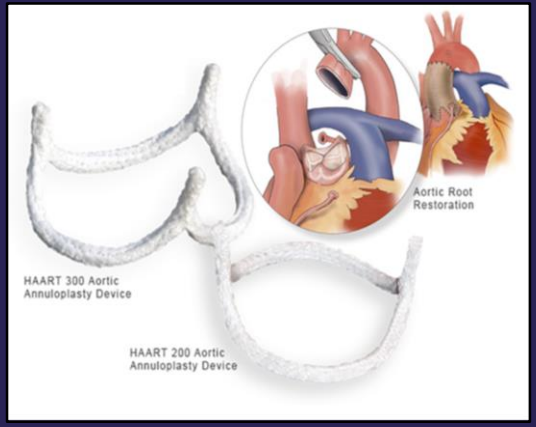
Zakkar M, Lansac E et al. *Eur J Cardiothorac Surg*. 2020;57:308-16

REIMPLANTATION PROXIMAL SUTURE LINE



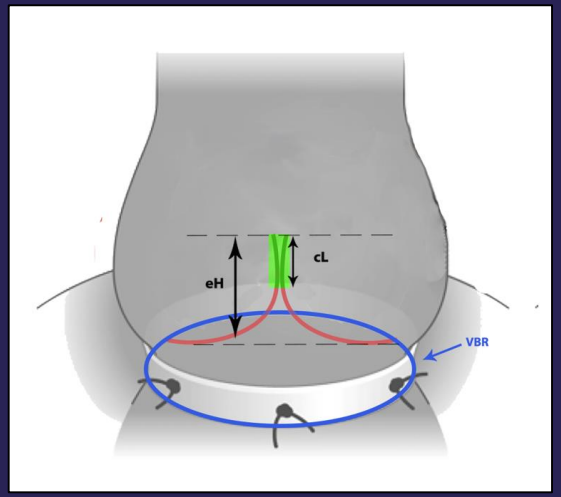
de Kerchove et al. *Ann Cardiothorac Surg*. 2013;2(1):105-112

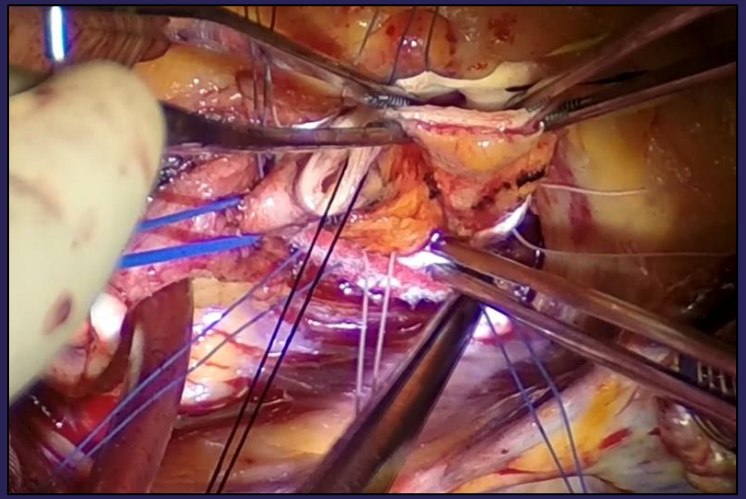
INTERNAL RING



https://biostable-s-e.com/haart-aortic-valve-repair-technologies/

External annuloplasty: teflon ring





Chirichilli I, Irace FG, Salica A, D'Aleo S, Guerrieri Wolf L, Garufi L, De Paulis R. Root Reimplantation and Aortic Annuloplasty With External Ring in Bicuspid Aortic Valve: An Anatomical Comparison. Semin Thorac Cardiovasc Surg. 2022 Autumn;34(3):844-851

Sizing made easy (De Paulis technique)

a strip of 8 cm

a strip of 9 cm

External annular diameter 26 mm

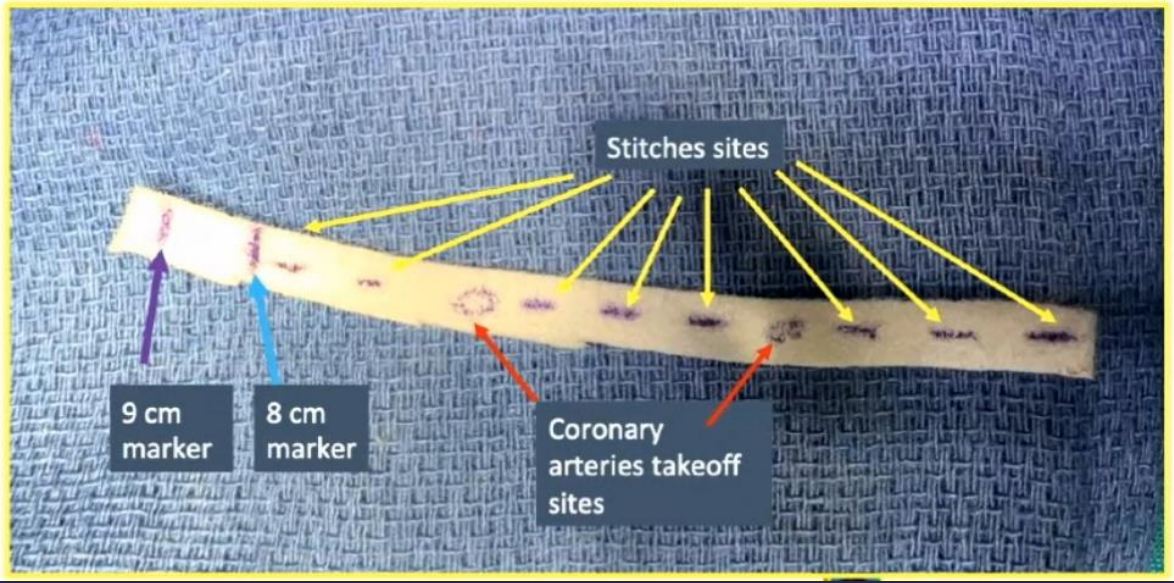
External annular diameter 28 mm

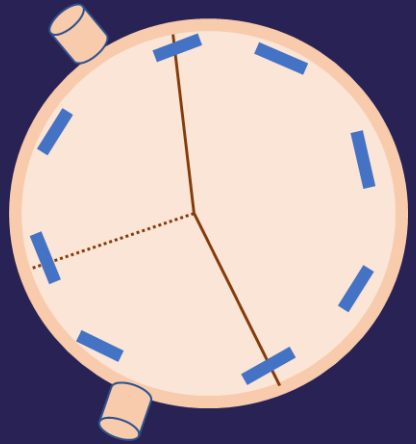
21 mm

23 mm

Desired internal annular diameter

Ring annular implant - sizing

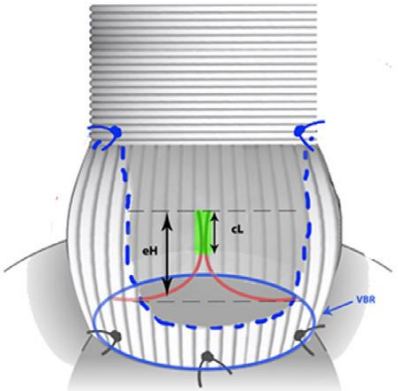




ROOT REIMPLANTATION AND AORTIC ANNULOPLASTY WITH EXTERNAL RING IN BICUSPID AORTIC VALVE: AN ANATOMICAL COMPARISON

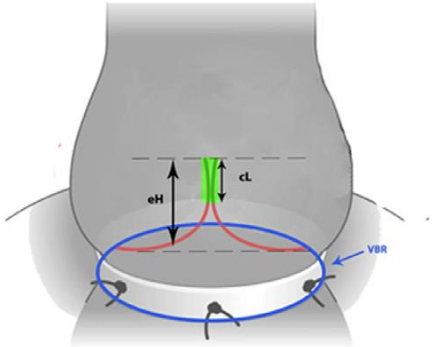
METHODS: We compared two homogeneous (age and BSA) groups of 10 patients each with bicuspid aortic valve who underwent reimplantation procedure with Valsalva graft or external ring annuloplasty. ECG-gated CT-Scan of the aortic root was performed and pre- and post-operative geometric characteristics were compared.

REIMPLANTATION



Post-op eH: **10.1 ± 2.0 mm**
Post-op cL: **7.6 ± 1.6 mm**

EXTERNAL RING



Post-op eH: **10.9 ± 2.1 mm**
Post-op cL: **7.5 ± 1.9 mm**

RESULTS: This anatomical ECG-gated CT Scan study in bicuspid aortic valves shows similar post-operative parameters, in terms of Effective Height and Coaptation Length, between reimplantation with Valsalva graft and external ring annuloplasty

IMPLICATIONS: Both reimplantation with Valsalva graft and external aortic ring annuloplasty achieve an efficient aortic annuloplasty with similar anatomical and functional results on bicuspid aortic valves

eH: Effective Height; **cL:** Coaptation Lenght; **VBR:** Virtual Basal Ring; **ECG:** Electrocardiogram; **CT:** Computed Tomography

Semin Thorac Cardiovasc Surg. 2022 Autumn;34(3):844-851

Different annuloplasty techniques

TABLE 1. Summary of the reviewed series

Technique	N [Ref]	AV morphology	Valve assessment	Mean follow-up, mo	Freedom from reoperation, 1-/5-y (%)	Control	Cusp repair
Subcommissural suture	166 [17]	TAV	V	NA	NA/NA	+	+
	100 [10]	BAV	M	48	NA/88	–	+
External ring	177 [1]	UAV, BAV TAV	M*	41	100/100 97/88	–	+
Internal ring	65 [18]	TAV	V	24	95/NA	–	+
	16 [19]	UAV, BAV	M	NA	NA/NA	–	+
Internal/external ring	52 [20]	TAV	V	45	NA/NA	–	+
Double external ring	37 [21]	UAV, BAV, TAV	M*	18	90/75	+	+
STJ remodeling	5 [6]	TAV	V	10	NA/NA	–	–
	103 [12]	NA	V	68	NA/NA	–	+
"Basal" suture annuloplasty	1024 [14]	BAV	M	56	97/94	+	+
	164 [23]	BAV	M	27	96/93	+	+
"Anatomical" suture annuloplasty	22 [25]	BAV, TAV	V	NA	NA	–	+

Data on follow-up and freedom from aortic valve reoperation refer to the annuloplasty group in each series. Control indicates control group without annuloplasty; + indicates present or was performed; and – indicates not present or was not performed. *N*, Number of individuals with annuloplasty; *Ref*, reference; *AV*, aortic valve; *TAV*, tricuspid aortic valve; *V*, visu … *J*, sinotubular junction. *Nc …

Federspiel JM, Ehrlich T, Abeln K, Schäfers HJ. *JTCVS techniques* 2021;7:98-102.

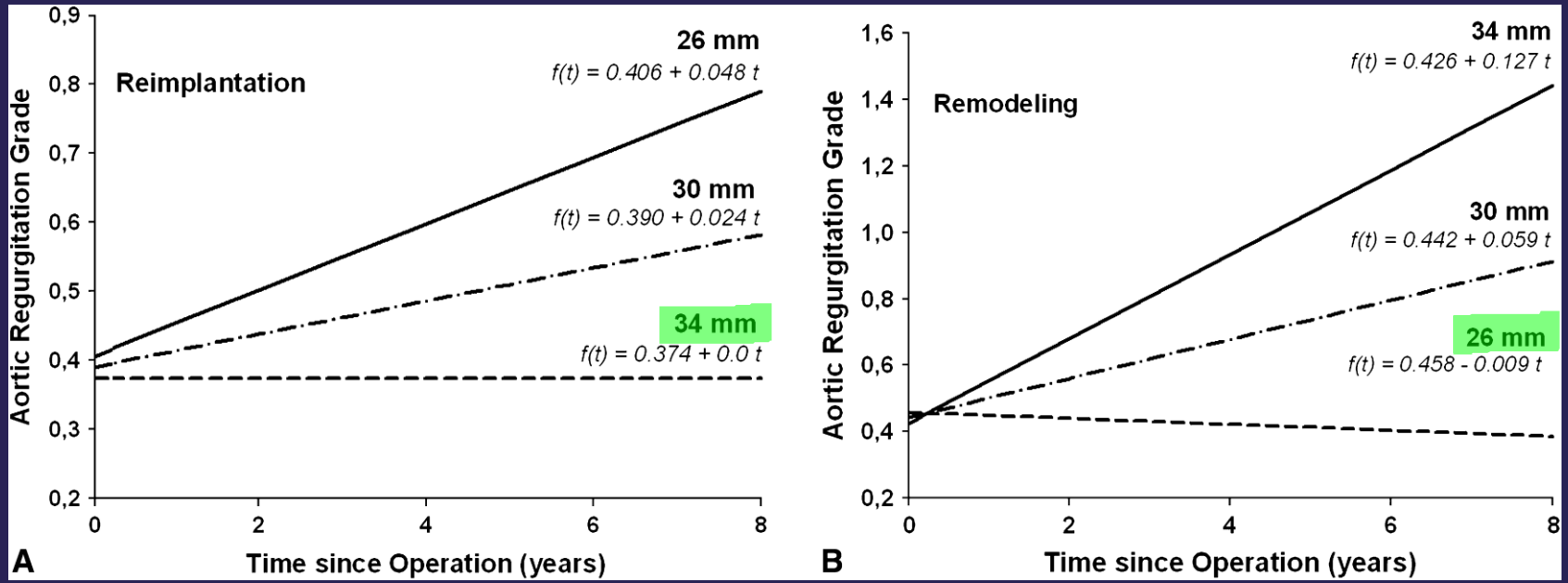
The results of the different techniques are difficult to judge beacuse of lack of control groups and control of confounding factors

TAV

Factors associated with the development of aortic valve regurgitation over time after two different techniques of valve-sparing aortic root surgery

Thorsten Hanke, MD,[a,*] Efstratios I. Charitos, MD,[a,*] Ulrich Stierle, MD,[a,*] Derek Robinson, MA, MSc, DPhil, CStat,[b] Armin Gorski, MD,[c] Hans-H. Sievers, MD,[a] and Martin Misfeld, MD, PhD[a]

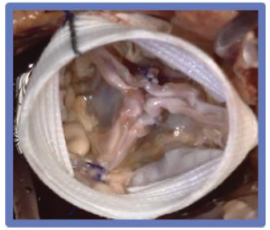
Association of preoperative aortic annulus diameter and AR grade with time



The Journal of Thoracic and Cardiovascular Surgery • February 2009

Aortic Valve Repairs
March 1996 ➤ November 2019
n = 1102

Only TAV with Severe AR,
without Dilatation
Study Cohort: n = 127
Median Follow-Up: 6.4 Years



Valve-Sparing Reimplantation (n = 25)
External Ring Annuloplasty (n = 8)

Cusp Repair Techniques (97%)
Previous Cardiac Surgery (21%)
CPB 139 min [IQR 118:167]

Cabrol Annuloplasty (n = 93)

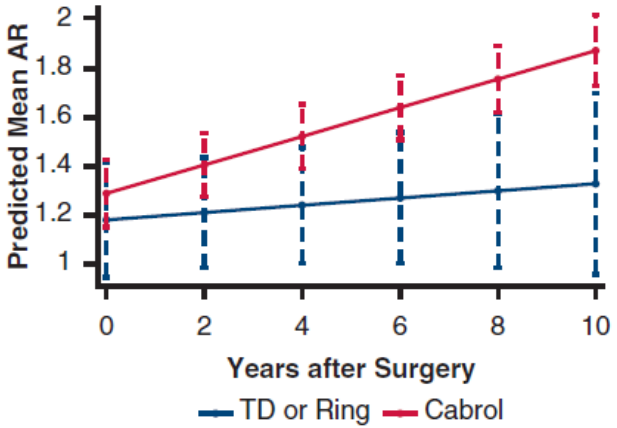
Cusp Repair Techniques (92%)
Previous Cardiac Surgery (18%)
CPB 94 min [IQR 74:121]

Tamer et al

Late results of aortic valve repair for isolated severe aortic regurgitation

Saadallah Tamer, MD,[a] Stefano Mastrobuoni, MD, MMsc,[a] David Vancraeynest, MD, PhD,[a] Guillaume Lemaire, MD,[b] Emiliano Navarra, MD,[a] Gebrine el Khoury, MD,[a] and Laurent de Kerchove, MD, PhD[a]

Annuloplasty Technique



Marginal impact of annuloplasty technique at this stage on repair durability.

J Thorac Cardiovasc Surg. 2021 Apr 16:S0022-5223(21)00612-7.

Anand J et al.

Significance of Effective Height and Mechanism of Regurgitation in Tricuspid Aortic Valve Repair.

Ann Thorac Surg. 2022 Jun 30:S0003-4975(22)00848-7.

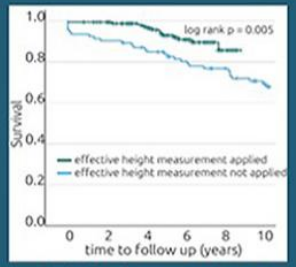
Study design

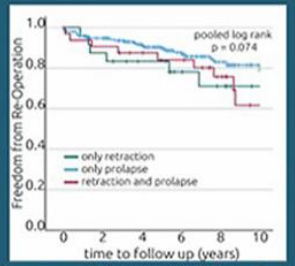
STUDY POPULATION

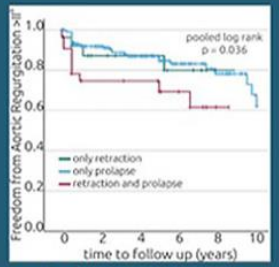
264 patients with severe non dilated aortic regurgitation

Mean clinical follow-up 81 ± 43 months

Outcome







Effective height is associated with improved long-term survival

Freedom from AI is higher in patients with prolapse compared to retraction

Conclusion

Repair of the regurgitant tricuspid aortic valve can be performed for cusp prolapse with good durability

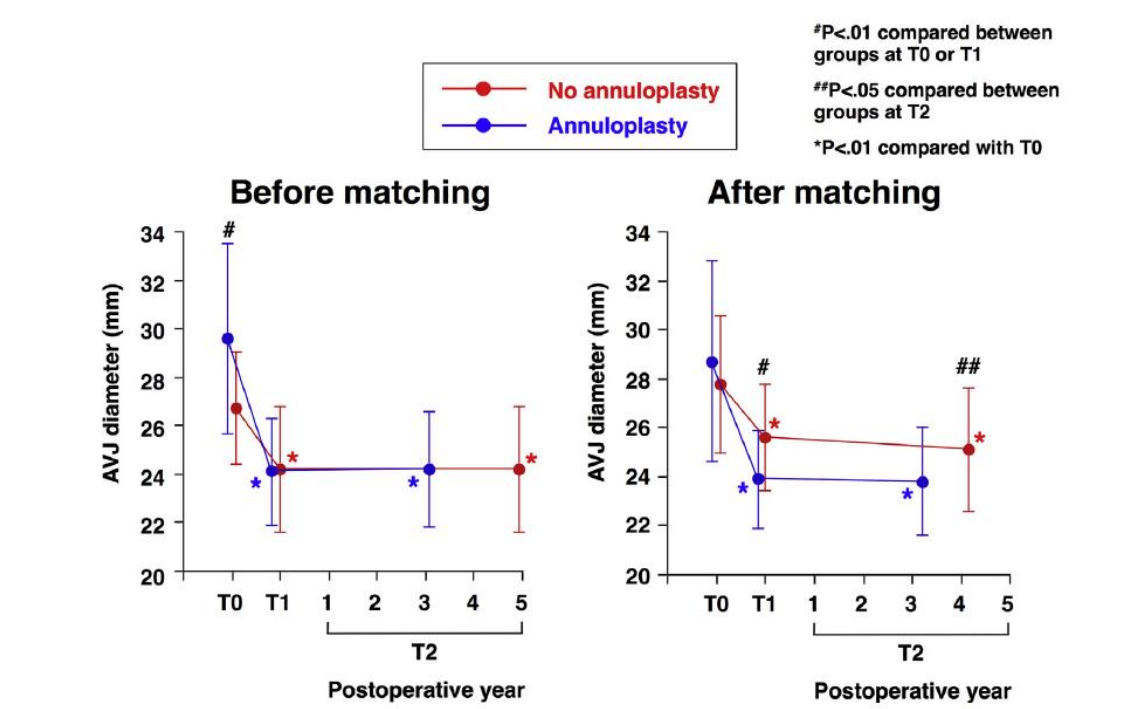
The intraoperative measurement of effective and geometric height leads to improved late results

Cusp retraction is associated with poorer results than prolapse

The use of circular annuloplasty had no significant influence on survival or durability.

Aortic annulus does not dilate over time after aortic root remodeling with or without annuloplasty

Takashi Kunihara, MD, PhD,[a] Satoshi Arimura, MD,[a] Fumihiro Sata, MD, PhD,[b] Christian Giebels, MD,[c] Ulrich Schneider, MD,[c] and Hans-Joachim Schäfers, MD, PhD[c]



The Journal of Thoracic and Cardiovascular Surgery • March 2018

Aortic annulus does not dilate over time after aortic root remodeling with or without annuloplasty

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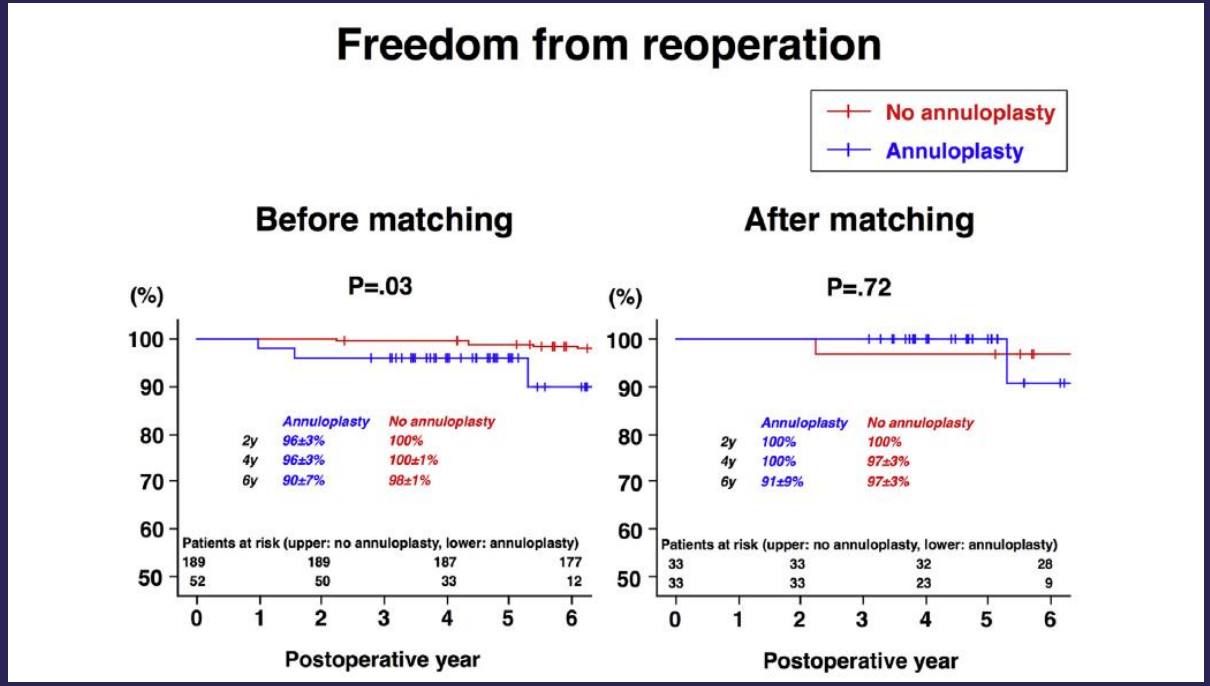


The Journal of Thoracic and Cardiovascular Surgery • March 2018

TAV with CTD

doi:10.1510/icvts.2011.267401

INTERACTIVE CARDIOVASCULAR AND THORACIC SURGERY

Interactive CardioVascular and Thoracic Surgery 13 (2011) 189-197

www.icvts.org

Best evidence topic - Aortic and aneurysmal

Aortic valve-sparing operations in aortic root aneurysms: remodeling or reimplantation?

Mohammad Rahnavardi[a,b,*], Tristan D. Yan[a,b], Paul G. Bannon[a,b], Michael K. Wilson[a,b]

[a]*Department of Cardiothoracic Surgery, University of Sydney, Royal Prince Alfred Hospital, Sydney, NSW, Australia*
[b]*The Baird Institute for Applied Heart and Lung Surgical Research, Sydney, NSW, Australia*

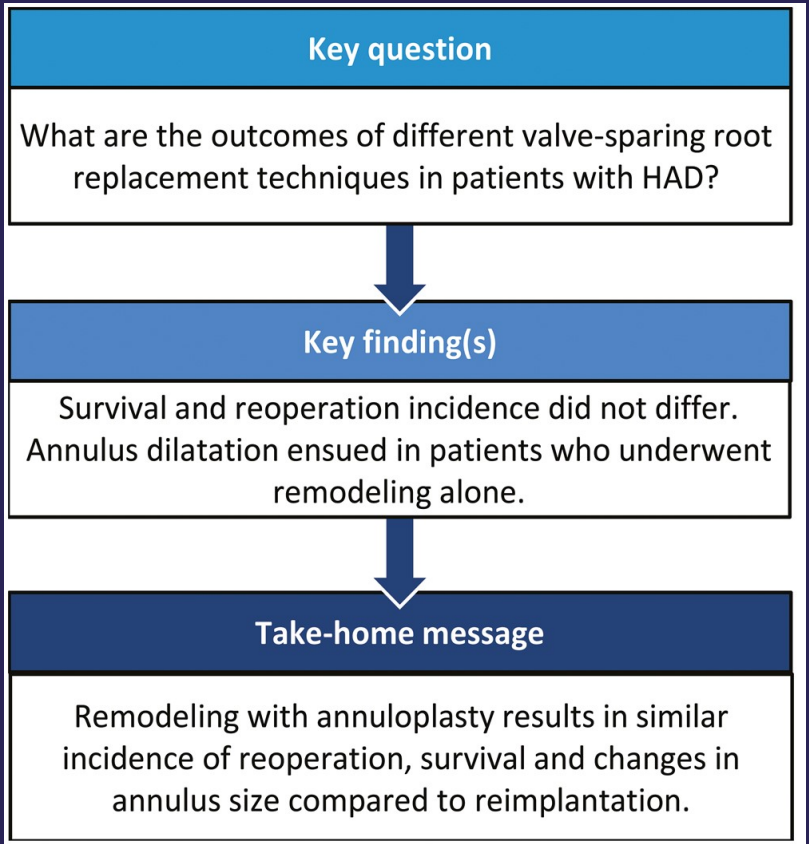
Received 2 Februray 2011; received in revised form 18 April 2011; accepted 21 April 2011

Summary

A best evidence topic was written according to a structured protocol. The question addressed was whether the reimplantation (David) technique or the remodeling (Yacoub) technique provides the optimum event free survival in patients with an aortic root aneurysm suitable for an aortic valve-sparing operation. In total, 392 papers were found using the reported search criteria, of which 14 papers provided the best evidence to answer the clinical question. A total of 1338 patients (Yacoub technique in 606 and David technique in 732) from 13 centres were included. In most series, cardiopulmonary bypass time and aortic cross-clamp time were longer for the David technique compared to the Yacoub technique. Early mortality was comparable between the two techniques (0–6.9% for the Yacoub technique and 0–6% for the David technique). There is a tendency for a higher freedom from significant long-term aortic insufficiency in the David group than the Yacoub group, which does not necessarily result in a higher reoperation rate in the Yacoub group. In the largest series reported, freedom from a moderate-to-severe aortic insufficiency at 12 years was 82.6±6.2% in the Yacoub and 91.0±3.8% in the David group (P=0.035). Freedom from reoperation at the same time point was 90.4±4.7% in the Yacoub group and 97.4±2.2% in the David

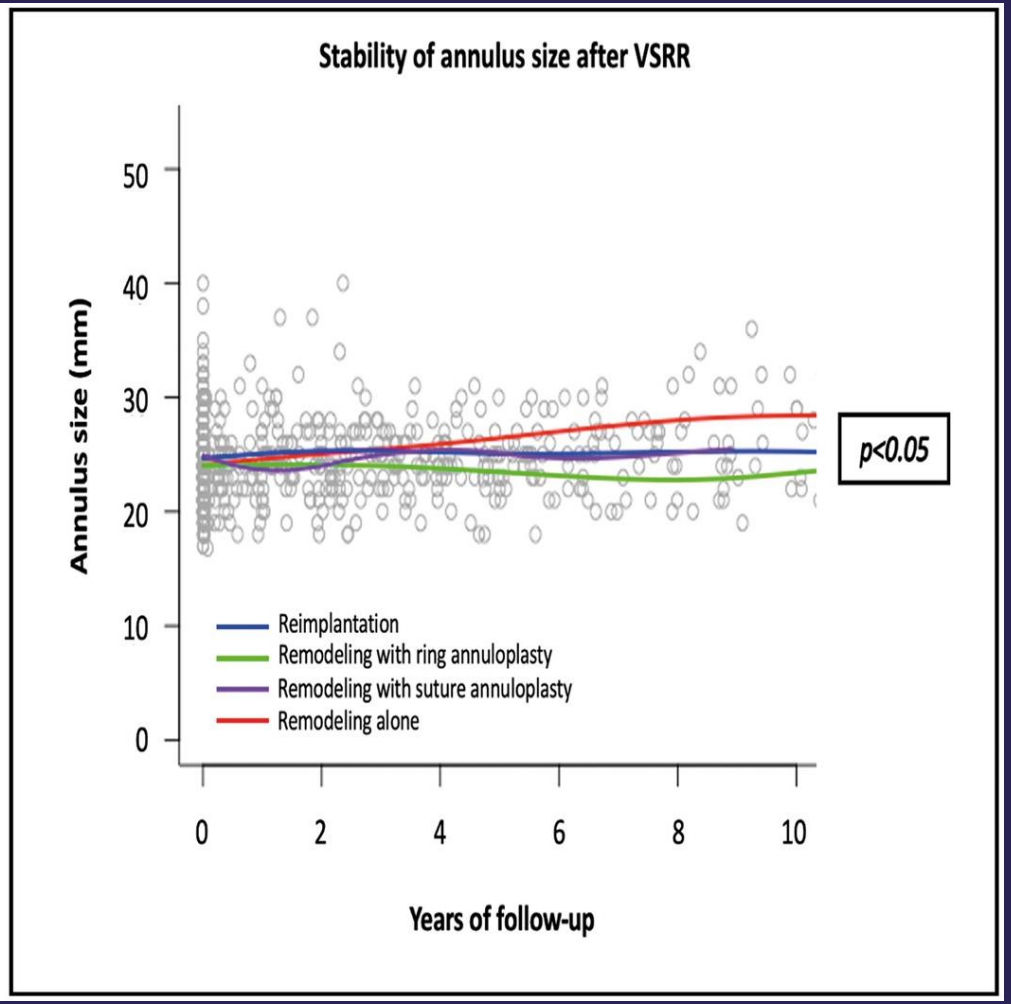
dence in the current review indicates comparable results for both techniques in a bicuspid aortic valve. Current evidence is in favour of the David rather than the Yacoub technique in pathologies such as Marfan syndrome, acute type A aortic dissection, and excessive annular dilatation that may impair aortic root integrity. Careful selection of patients for each technique and successful restoration of normal cusp geometry are the keys to success in aortic valve-sparing operations.

Chauvette V, Kluin J, de Kerchove L, El Khoury G, Schäfers HJ, Lansac E, El-Hamamsy I. **Outcomes of valve-sparing surgery in heritable aortic disorders: results from the AVIATOR registry**. Eur J Cardiothorac Surg. 2022 Aug 3;62(3):ezac366.



237 patients

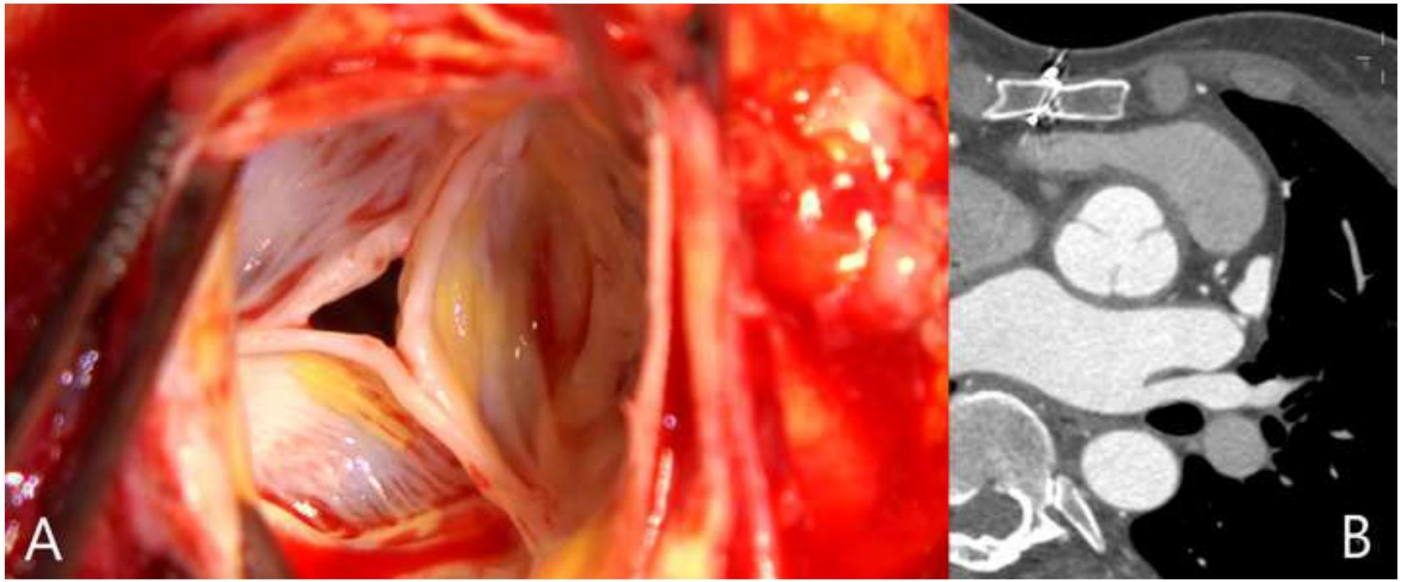
- 100 reimplantation
- 100 remodelling + ring annuloplasty
- 76 remodelling + suture annuloplasty
- 34 remodelling alone



Changes in aortic annulus dimension were significantly different at 10 years, a difference that started to emerge 4 years after surgery.

An aortic valve 21 years after repair *(in press)*

Folino G, Scaffa R, Salica A, De Paulis R



A 52-year-old woman with Marfan syndrome was operated for an aortic arch aneurysm. She had undergone an aortic valve sparing with sinuses reconstruction 21 years earlier. During surgery the aortic valve was directly evaluated

Very long-term follow-up of aortic valve reimplantation with Valsalva graft.

De Paulis R et al. (in press)

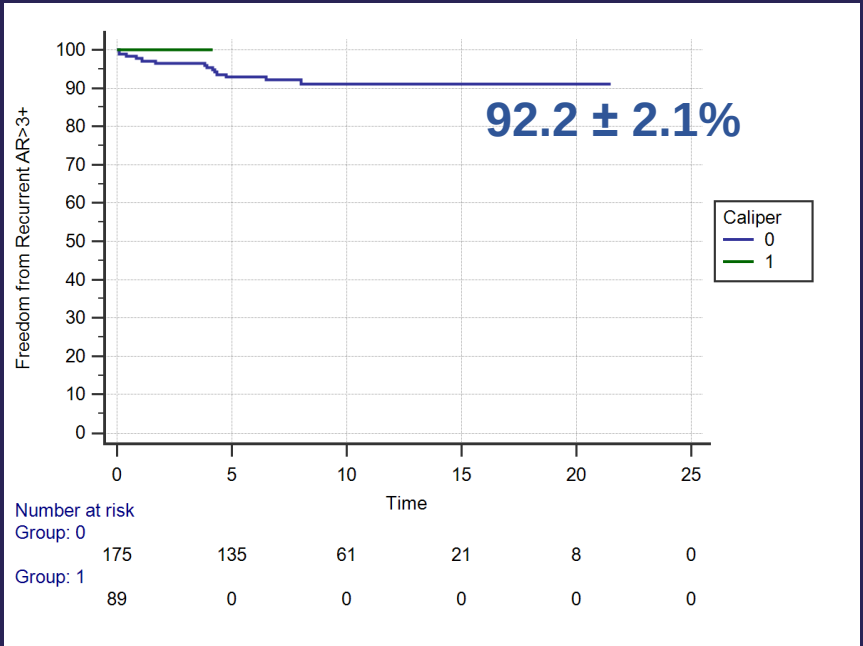
TABLE I. Preoperative clinical and echocardiographic characteristics

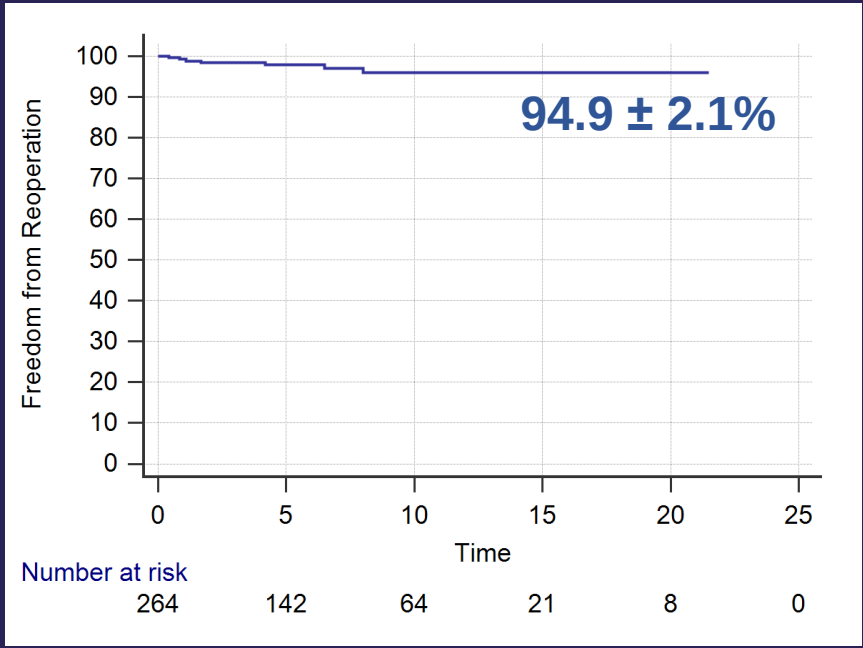
CHARACTERISTICS	RESULTS
Number of Patients	265
Male sex,	231 (87.2)
Age, (years)	
Mean	52.9 ± 13.4
Range	13 – 77
Body Surface Area, m^2	2.04 ± 0.21
Associated Pathologies	
Marfan sd	28 (10.6)
Loyes-Dietz sd	4 (1.5)
Type A Aortic Dissection	9 (3.4)
Previous Cardiac surgery	7 (2.6)
Coronary Artery Disease	23 (8.7)
NYHA class	2.01 ± 0.98
Euroscore 2	2.33 ± 0.98

Preoperative Findings	
LV Ejection Fraction, %	59.9 ± 6.1
LVEDV, ml	132.9 ± 53.1
LVESV, ml	54.6 ± 30.5
LVEDD, mm	53.2 ± 7.3
LVESD, mm	35.4 ± 7.2
Mitral Regurgitation > 2+, n (%)	17 (6.5)
Bicuspid aortic valve	50 (18.9)
Type 1 LR	36 (13.5)
Type 1 RN	1 (0.4)
Type 1 LN	1 (0.4)
Type 0 AP	8 (3.0)
Type 0 LL	3 (1.1)
Type 2	1 (0.4)
Aortic Regurgitation	
0	36 (13.6)
1+	81 (30.1)
2+	59 (22.3)
3+	45 (17.0)
4+	44 (16.6)
Eccentric Jet	51 (19.2)
Aortic Diameters, mm	
Aortic Annulus	25.0 ± 2.8
Valsalva Sinuses	50.1 ± 3.9
Sino-Tubular Junction	43.5 ± 5.3
Tubular Ascending Aorta	46.3 ± 7.2

Values are presented as mean ± standard deviation or frequencies (%).

Very long-term follow-up of aortic valve reimplantation with Valsalva graft.
De Paulis R et al. (in press)

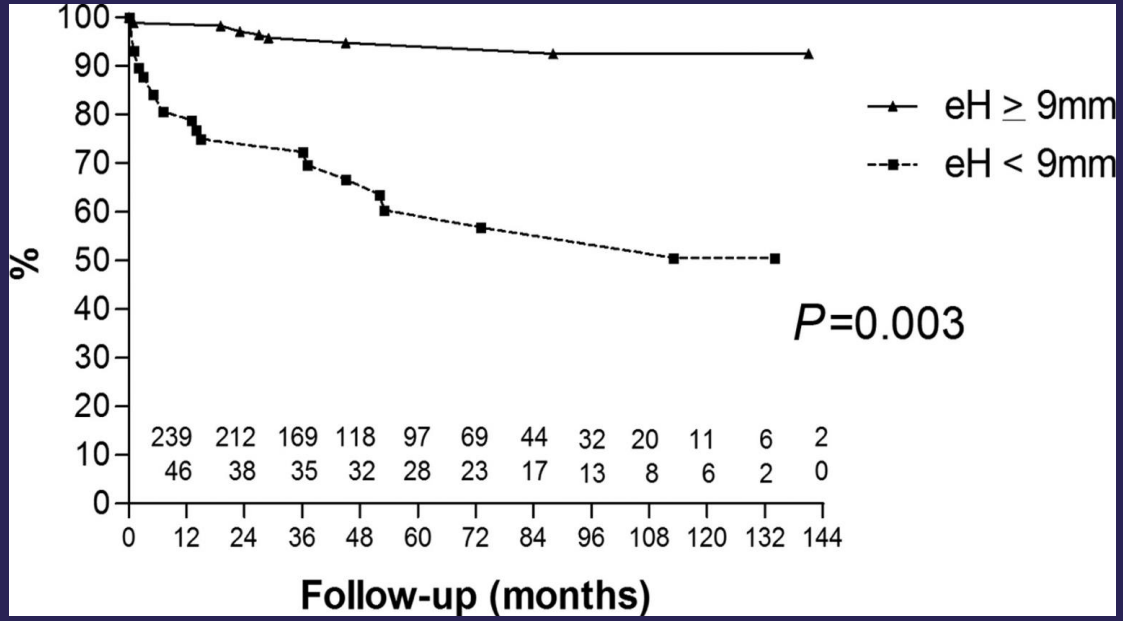




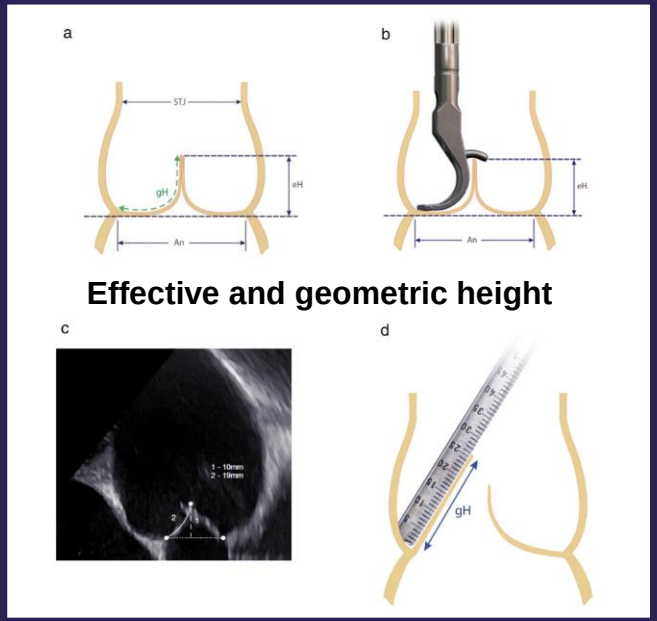
BAV

Valve configuration determines long-term results after repair of the bicuspid aortic valve.

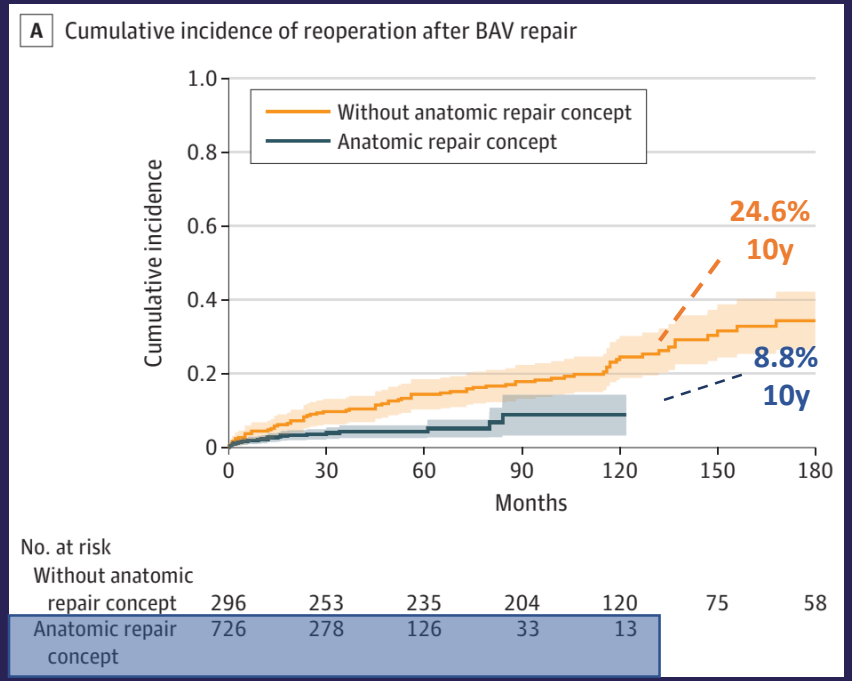
Aicher D, Kunihara T, Abou Issa O, Brittner B, Graber S, Schafers HJ. Circulation 2011;123:178-85



Actuarial freedom from reoperation after AV repair in patients with a BAV depending on postoperative achieved eH



BAV repair: outcomes



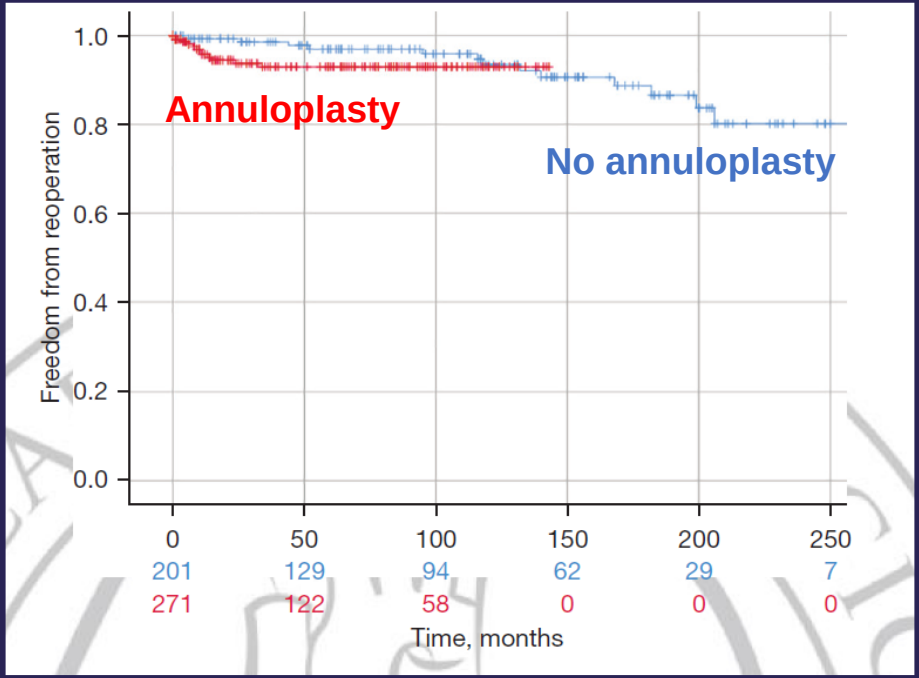
Mid- long-term results

Schneider U et al. Long-term results of differentiated anatomic reconstruction of bicuspid aortic valves. JAMA Cardiol. 2020;16:e203749

Featured Article

Twenty-five years' experience with root remodeling and bicuspid aortic valve repair

Lennart Froede, Karen B. Abeln, Tristan Ehrlich, Susanne K. Feldner, Hans-Joachim Schäfers



Ann Cardiothorac Surg 2022 | https://dx.doi.org/10.21037/acs-2021-bav-208

European Journal of Cardio-Thoracic Surgery 44 (2013) 316–323
doi:10.1093/ejcts/ezt045 Advance Access publication 8 March 2013

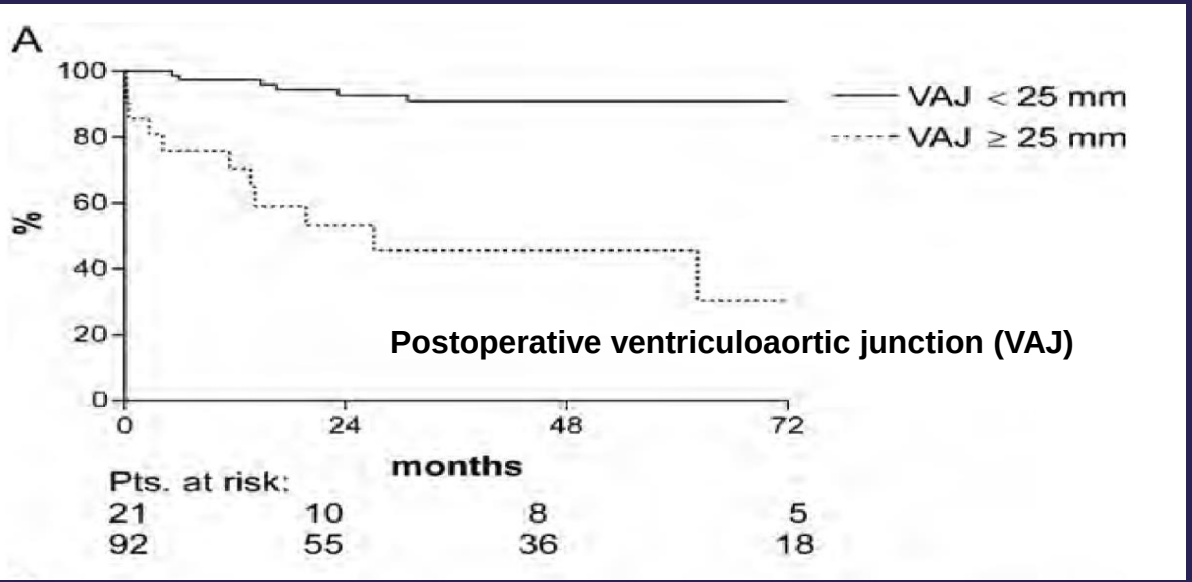
ORIGINAL ARTICLE

Winner of the 2012 EACTS Lillehei Award

Effect of annulus dimension and annuloplasty on bicuspid aortic valve repair†

Emiliano Navarra[a], Gebrine El Khoury[a], David Glineur[a], Munir Boodhwani[d], Michel Van Dyck[c], Jean-Louis Vanoverschelde[b], Philippe Noirhomme[a] and Laurent de Kerchove[a,*]

Freedom from recurrent AR>1+



Postoperative ventriculoaortic junction (VAJ)

Long-term durability of bicuspid aortic valve repair: a comparison of 2 annuloplasty techniques

Christophe de Meester[a], Jean-Louis Vanoverschelde[a,b], Jama Jahanyar [c], Saadallah Tamer [c], Stefano Mastrobuoni [a,c], Michel Van Dyck[d], Emiliano Navarra[a,c], Alain Poncelet [a,c], Parla Astarci[a,c], Gebrine el Khoury[a,c] and Laurent de Kerchove[a,c,*]

Key question

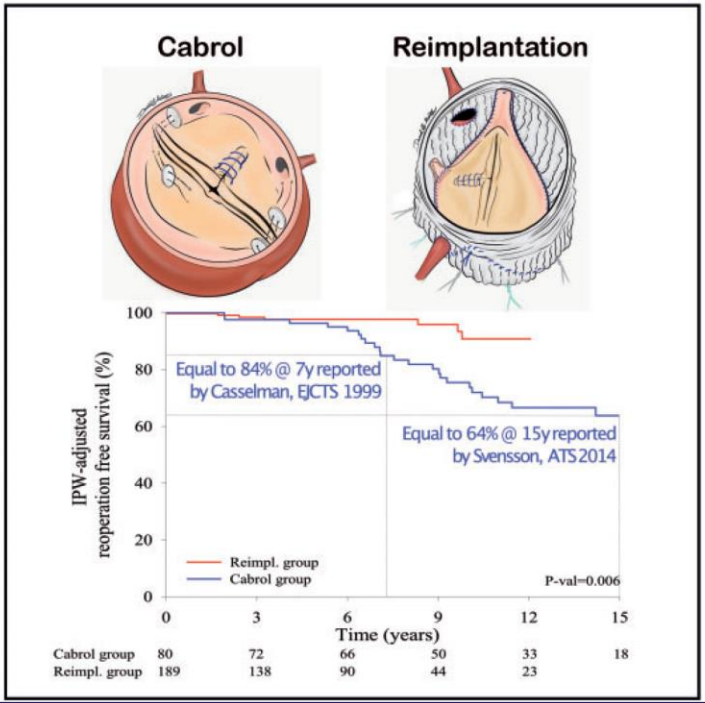
What is the impact on long-term durability of Cabrol annuloplasty versus the reimplantation technique in bicuspid aortic valve repair?

Key finding(s)

Reimplantation offers superior durability with equivalent survival; recurrence of AR is rare after reimplantation.

Take-home message

In bicuspid valve repair, Cabrol annuloplasty is obsolete. The 180° reimplantation technique is safe and effective in achieving the best long-term results.



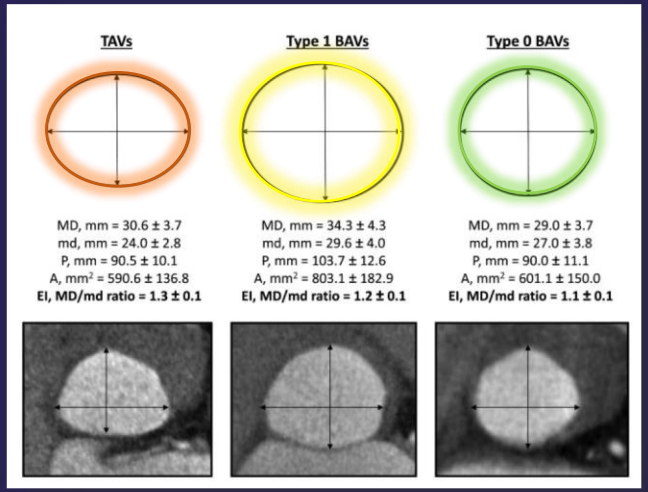
Eur J Cardiothorac Surg. 2021 Jul 30;60(2):286-294.

Morphological modification of the aortic annulus in tricuspid and bicuspid valves after aortic valve reimplantation: an electrocardiography-gated computed tomography study†

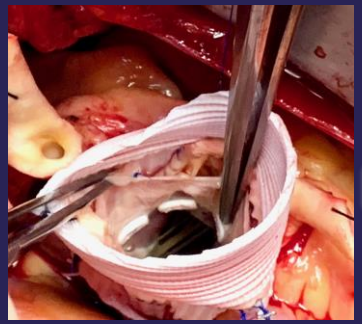
Ilaria Chirichilli[a], Francesco Irace[a], Luca Weltert[a], Kazumasa Tsuda[b], Raffaele Scaffa[a], Andrea Salica[a], Nicola Galea[c] and Ruggero De Paulis[a,*]

[a] Department of Cardiac Surgery, European Hospital, Rome, Italy
[b] First Department of Surgery, Hamamatsu University School of Medicine, Hamamatsu, Japan
[c] Department of Radiological, Oncological and Pathological Sciences, Sapienza University of Rome, Rome, Italy

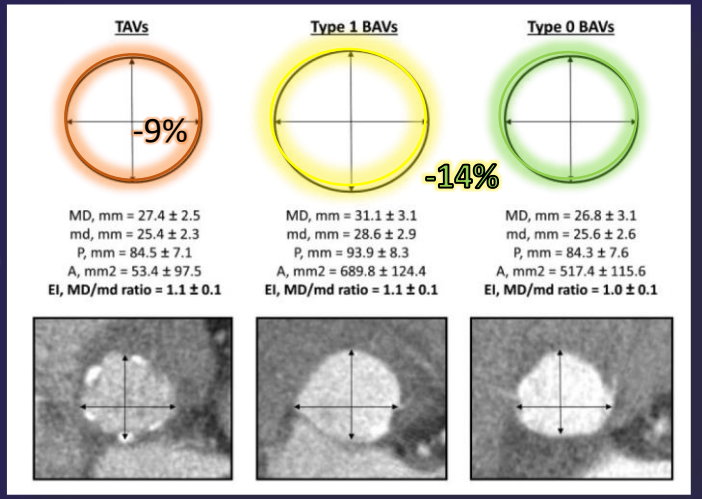
gradual spectrum of circularity



Preoperative
diastolic measurements of aortic annulus



similar roundness



Postoperative
diastolic measurements of aortic annulus

Eur J Cardiothorac Surg. 2019 Oct 1;56(4):778-784

Conclusion: What we know today

1. The majority of patients with AR have a large aortic annulus?

2. We lack sufficient scientific data to establish the superiority of one annuloplasty over the other

3. As long as the aortic annulus is supported, it does not matter what type of techinque is performed (remodeling, reimplantation or leaflets repair)

4. It is certain that it is always advisable to correct a dilated aortic annulus