A Modular and Geometric Approach to Aortic Valve Repair

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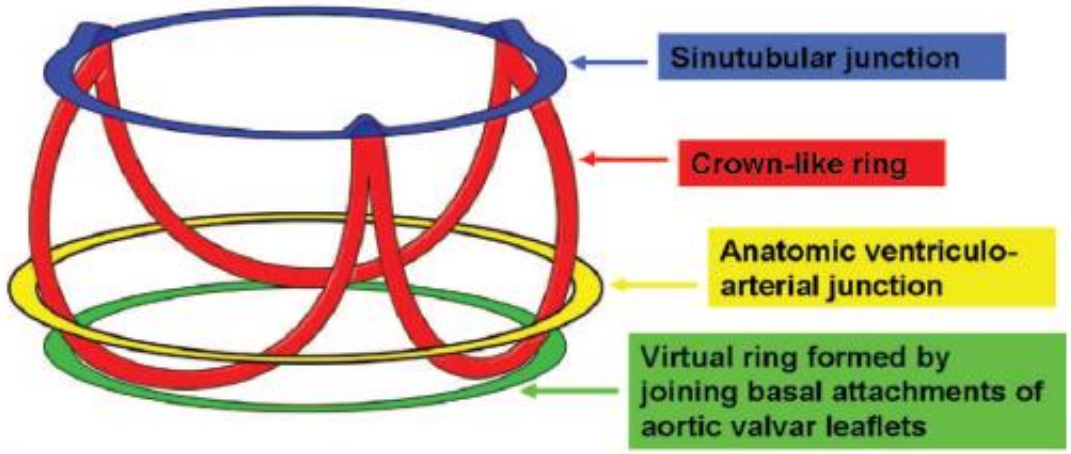
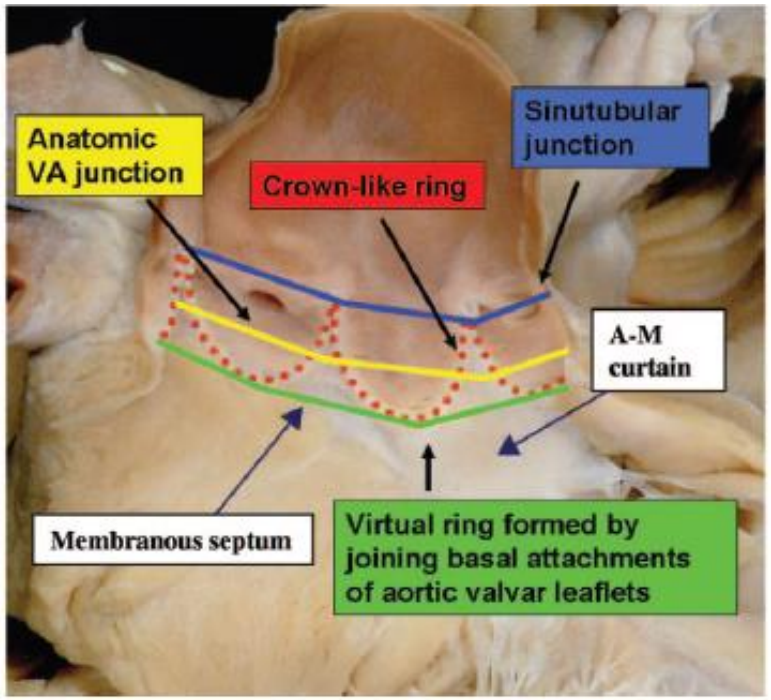
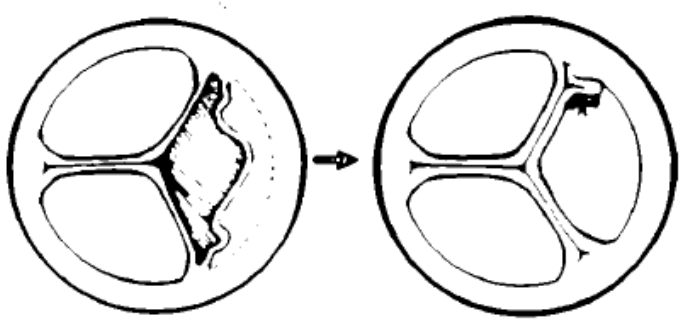
Morphology of the Aortic Valve



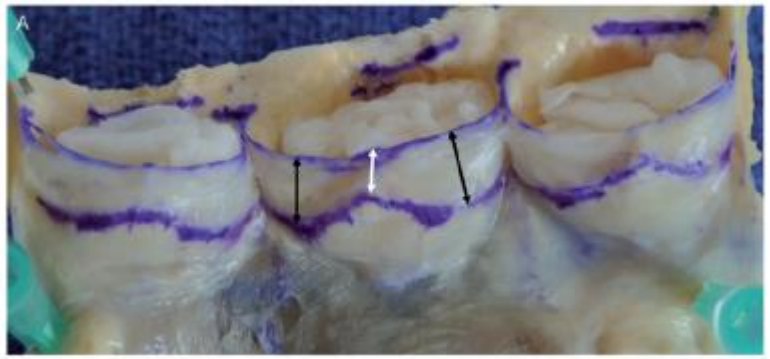


Piazza N, Anderson RH, Circ Cardiovasc Intervent 2008

✓ All cusp margins should be at equal height for competent valve function.



✓ Coaptation height should be high for secure diastolic function.



✓ Cusp configuration should be maintained under systemic pressure.

Duran CMG, J Card Surg 1994
De Kerchove L, Eur J Cardiothorac Surg 2018

Repair-oriented classification of aortic insufficiency: Impact on surgical techniques and clinical outcomes

Munir Boodhwani, MD, MMSc, Laurent de Kerchove, MD, David Glineur, MD, Alain Poncelet, MD, Jean Rubay, MD, Parla Astarci, MD, Robert Ver

Objective: Valve repa
aortic disease. Over t
strategy and can predi
valve repair.

Methods: From 1996
age – 54 ± 16 years;
hundred fifty three pa
had type III (restrictiv

Results: In-hospital m
pair. Functional classi
techniques being
47 [29–73] mont
95 ± 3%. Ten p
and from AV re
9%; 93 ± 5%) o

Conclusion: Ao
functional classif
niques required a
tion, is an impor

Limitations:

Purely echocardiographic, does not directly relate to morphology/pathology

Does not provide morphologic cut-offs for decision making

Insensitive in defining cusp prolapse in presence of marked aortic dilatation

Type III does not differentiate between restricion due to aortic dilatation and restriction due to cusp degeneration/retraction

Aortic Valve Repair Using a Differentiated Surgical Strategy

Frank Langer, MD; Diana Aicher, MD; Anke Kissinger, Olaf Wendler, MD; Henning Lausberg, MD; Roland Fries, MD; Hans-Joachim Schäfers, MD

Background—Reconstruction of the aortic valve for aortic regurgitation (AR) remains challenging, in part because of not only cusp or root pathology but also a combination of both can be responsible for this valve dysfunction. We have systematically tailored the repair to the individual pathology of cusps and root.

Methods—Between October 1995 and August 2003, aortic valve repair was performed in 282 of 493 patients undergoing surgery for AR and concomitant disease. Root dilatation was corrected by subcommissural plication (n=59), supracommissural aortic replacement (n=27), root remodeling (n=175), or valve reimplantation within a graft (n=24). Cusp prolapse was corrected by plication of the free margin (n=157) or triangular resection (n =36), cusp defects were closed with a pericardial patch (n=16). Additional procedures were arch replacement (n=114), coronary artery bypass graft (n=60) or mitral repair (n=24). All patients were followed-up (follow-up 99.6% complete), and cumulative follow-up was 8425 patient-months (mean, 33±27 months).

Results—Eleven patients died in hospital (3.9%). Nine patients underwent reoperation for recurrent AR (3.3%). Actuarial freedom from AR grade ≥II at 5 years was 81% for isolated valve repair, 84% for isolated root replacement, and 94% for combination of both; actuarial freedom from reoperation at 5 years was 93%, 95%, and 98%, respectively. No thromboembolic events occurred, and there was 1 episode of endocarditis 4.5 years postoperatively.

Conclusions—Aortic valve repair is feasible even for complex mechanisms of AR with a systematic and individually tailored approach. Operative mortality is low and mid-term durability is encouraging. The incidence of valve-related morbidity is low compared with valve replacement. (*Circulation*. 2004;110[suppl II]:II-67–II-73.)

A

A

C

M

R

Ir

Calcific degeneration

Cusp pathology

ELSEVIER

European Journal of Cardio-thoracic Surgery 28 (2005) 850–856

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Aortic root dilatation may alter the dimensions of the valve leaflets☆

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[a] *Heineman Medical Research Laboratory, Department of Thoracic and Cardiovascular Surgery, Carolinas Medical Center, Charlotte, NC, USA*

[b] *Division of Cardiovascular Surgery, Mayo Clinic, Rochester, MN, USA*

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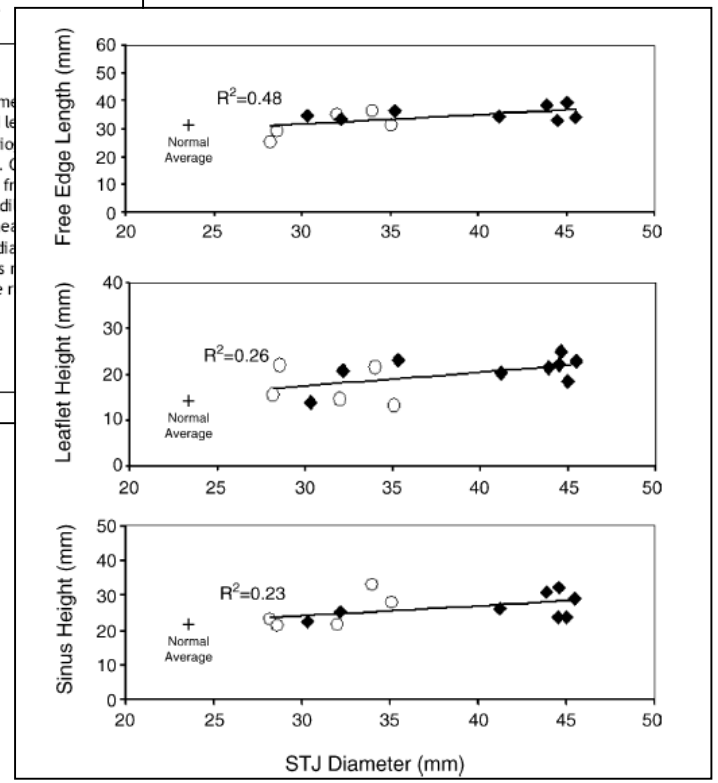
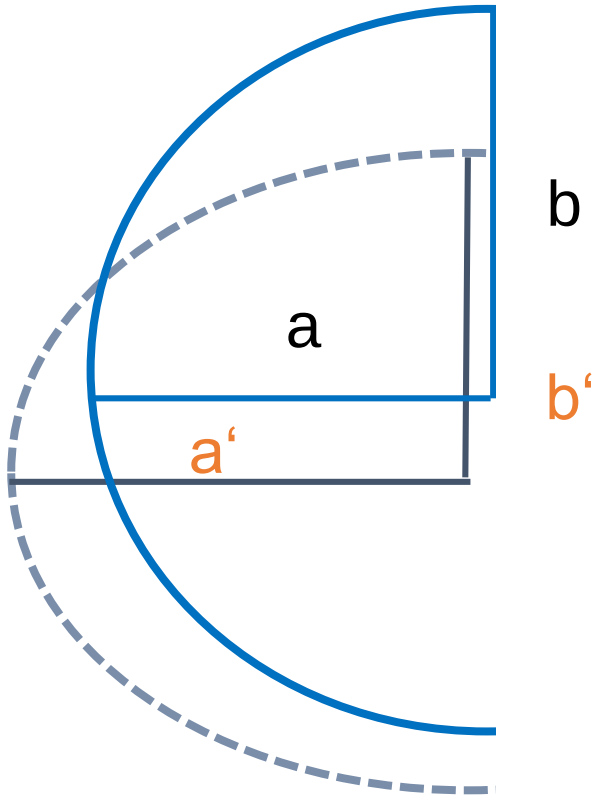
Abstract

Objective: Valve-sparing surgery can be used in patients with dilated aortic roots and aortic insufficiency (AI) but has not become practice, in part because the spared valve may be incompetent. Our goal was to study how the dimensions of the aortic root and le changed in such patients. **Methods:** Fourteen patients with dilated aortic root and AI were examined by transesophageal echocardio annulus diameter, sinotubular junction (STJ) diameter, sinus height, leaflet free-edge length, and leaflet height were measured. among these dimensions and with the AI grades were explored. Measurements were also made in 19 normal human aortic valves fr molds. **Results:** There was no evident change in the average diameter of the annulus between the normal valves and those in the di roots. The STJ diameter was obviously increased in the dilated aortic roots; the aortic sinuses also appeared to be taller and the lea than normal. The leaflet free-edge length, the leaflet height, and the sinus height were found to increase with the dilated STJ dia degree of AI was not found to correlate well with any of the dimensions measured. **Conclusions:** The dimensions of the leaflets parallel to aortic root dilatation with AI. Therefore, during valve sparing, it may be necessary to correct both the dilatation of the r leaflet free-edge length to achieve a competent valve.

Keywords: Aortic valve; Aortic root; Leaflets; Dimensions; Aneurysm; Insufficiency



Reduction of STJ and Cusp Prolapse

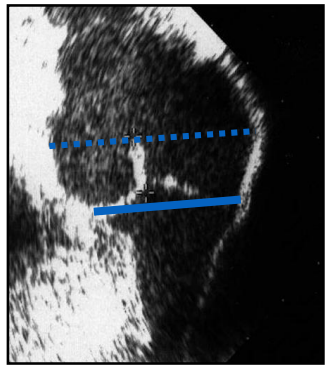


$$C_E = \pi \times \left[3/2 \times (a+b) - \sqrt{a \times b}\right]$$

$b \approx r_{aorta}$

$a \approx r_{cusp}$

$\Longrightarrow$ $r_{cusp} \approx 1 / r_{aorta}$



The perfect (?) aortic valve

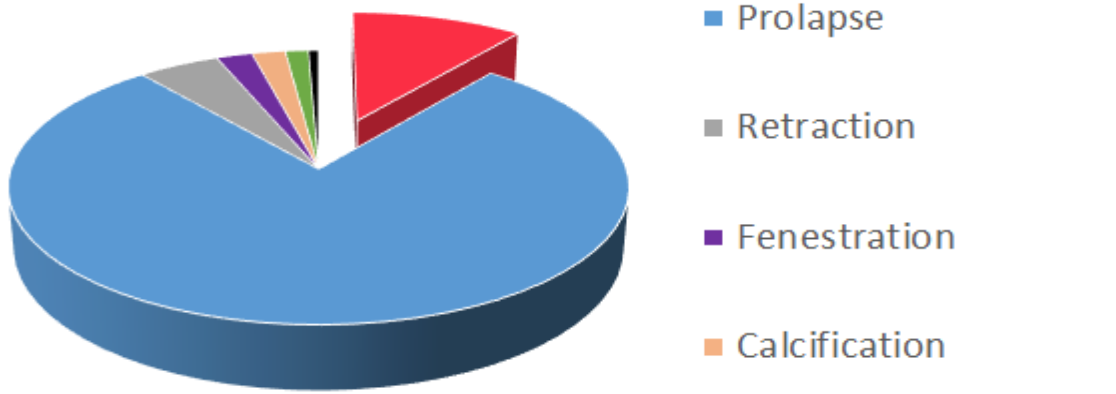
Valve preserving root replacement

- How frequent is cusp prolapse in VSRR?

Hypothesis: aortic dilatation + n

Normal cusps

Aortic root aneurysm, TAV
(n=659)

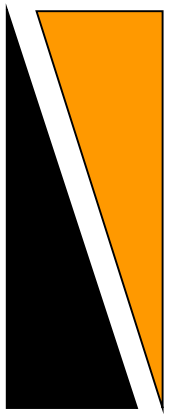


Normal cusps are rare in TAV and root aneurysm

Standardized Aortic Valve Repair

Assessment

Root pathology



Correction

Valve morphology
Cusp pathology

Standardized Aortic Valve Repair

1. Assessment root
2. Assessment cusps

3. Correction root
4. Correction cusps

Root Assessment

Echo:	
Maximum sinus diameter	► >40 - 45 mm?
ST diameter	► >30 - 35 (?)
Annular diameter	► > 25 mm(?)
Intraoperative:	
Annular diameter (!)	>25 -/ 28 mm?

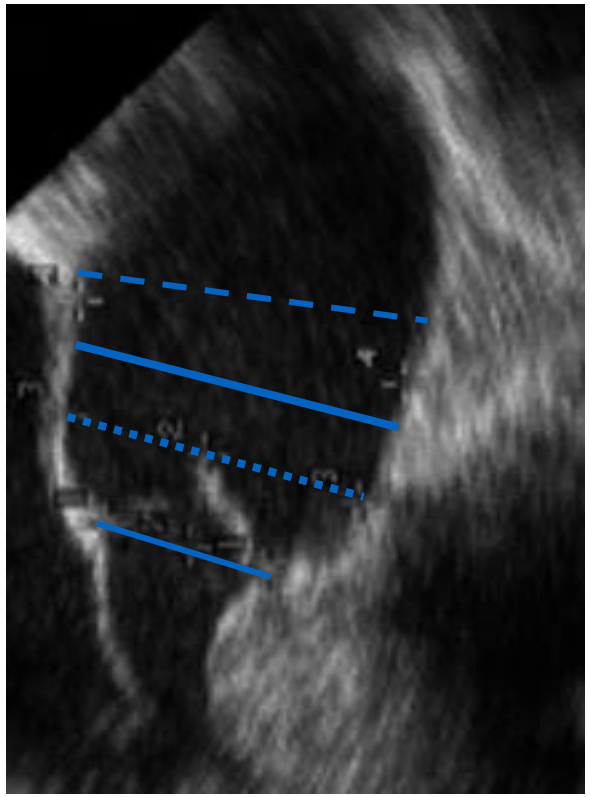
AI und TTE/TEE

Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?



Cusp Assessment

Echo:

- Valve morphology?
- Eccentricity of jet?

Intraoperative:

- Valve Morphology?
- Cusp height/configuration?
- Cusp substance?

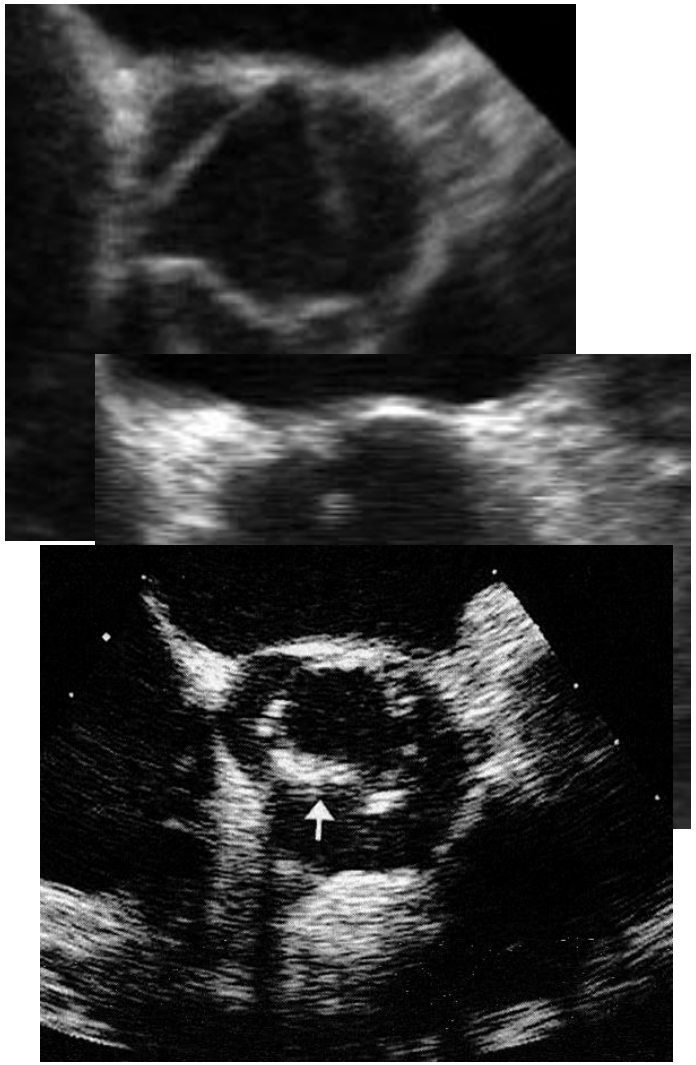
AI und TTE/TEE

Root dimensions

AV morphology

Prolapse

Calcification?



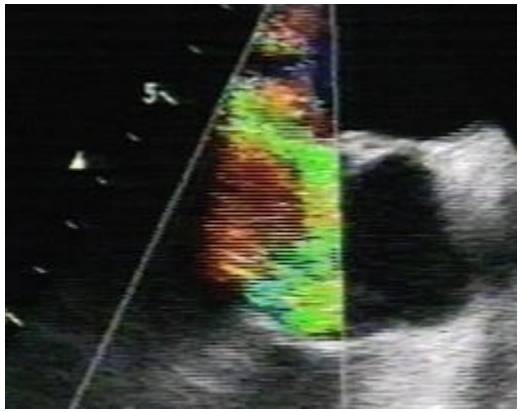
AI und TTE/TEE

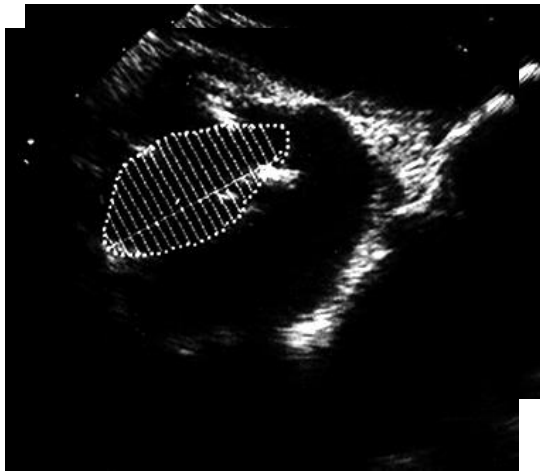
Root dimensions

AV morphology

Prolapse

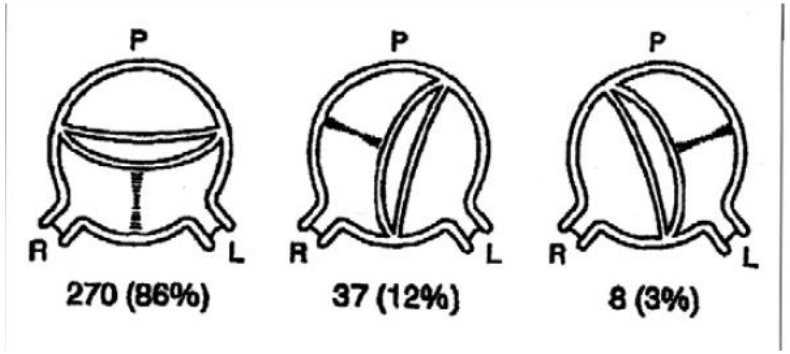
Calcification?



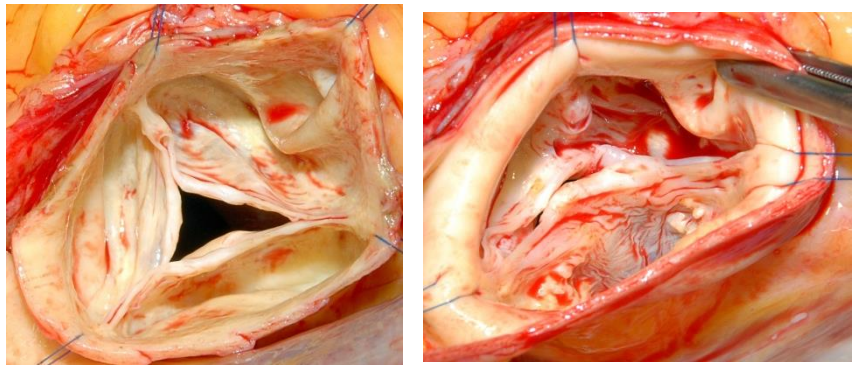


Bicuspid Aortic Valve (BAV) Morphology

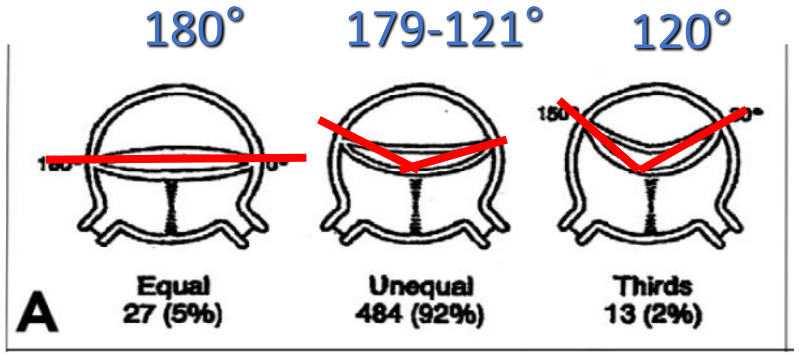
pattern of fusion



degree of fusion



commissural orientation



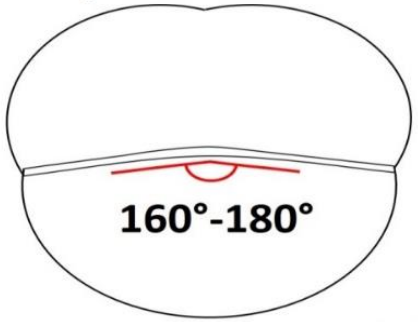
Sabet et al, *Mayo Clin Proc*, 1999;74:14-26

A BAV is not a BAV

Variability of repairable bicuspid aortic valve phenotypes: towards an anatomical and repair-oriented classification†

Laurent de Kerchove[a,*], Stefano Mastrobuoni[a], Lennart Froede[b], Saadallah Tamer[a], Munir Boodhwani[c], Michel van Dyck[d], Gebrine el Khoury[a] and Hans-Joachim Schäfers[b]

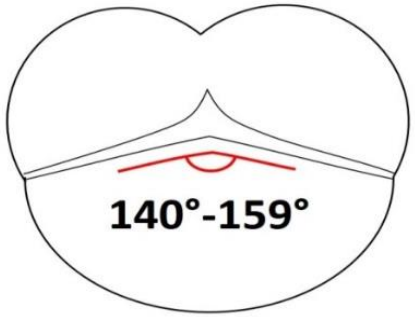
Symmetric BAV



40%

A

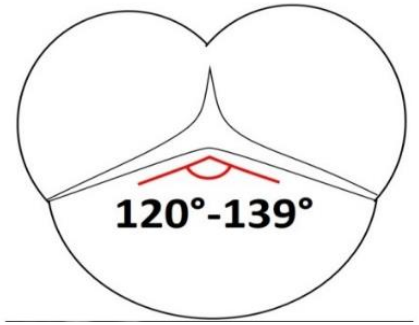
Asymmetric BAV



40%

B

Very Asymmetric BAV



20%

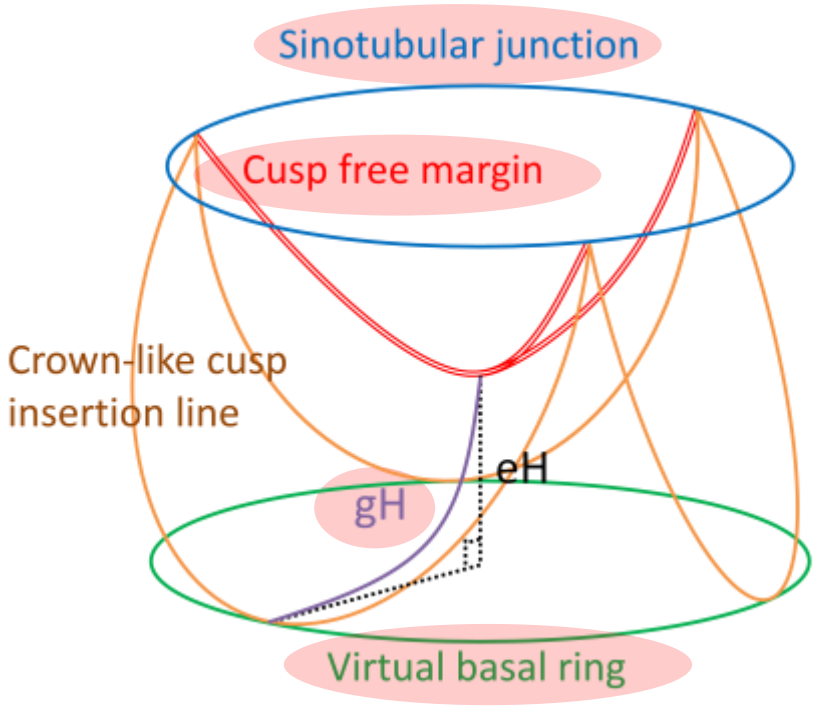
C

Keep/make symmetric BAV

Make/treat as TAV

European Journal of Cardio-Thoracic Surgery 56 (2019) 351–359

What determines Cusp and Valve Configuration?

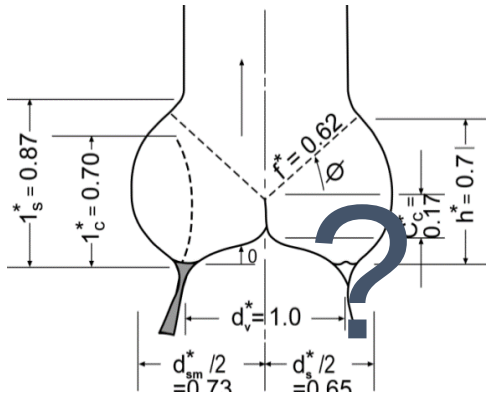


Commissural height (?)

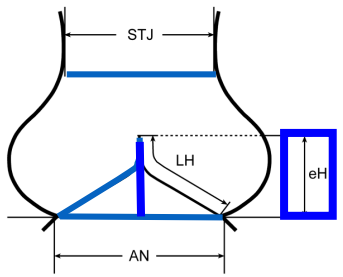
Sinus diameter (?)

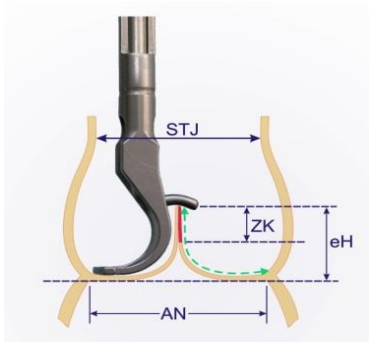
Aortic Valve Repair - Assessment

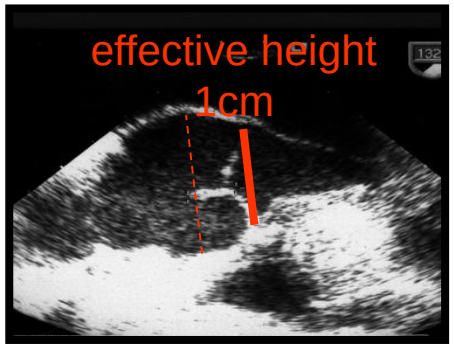
Configuration of cusps



Swanson, Circ Res 1974



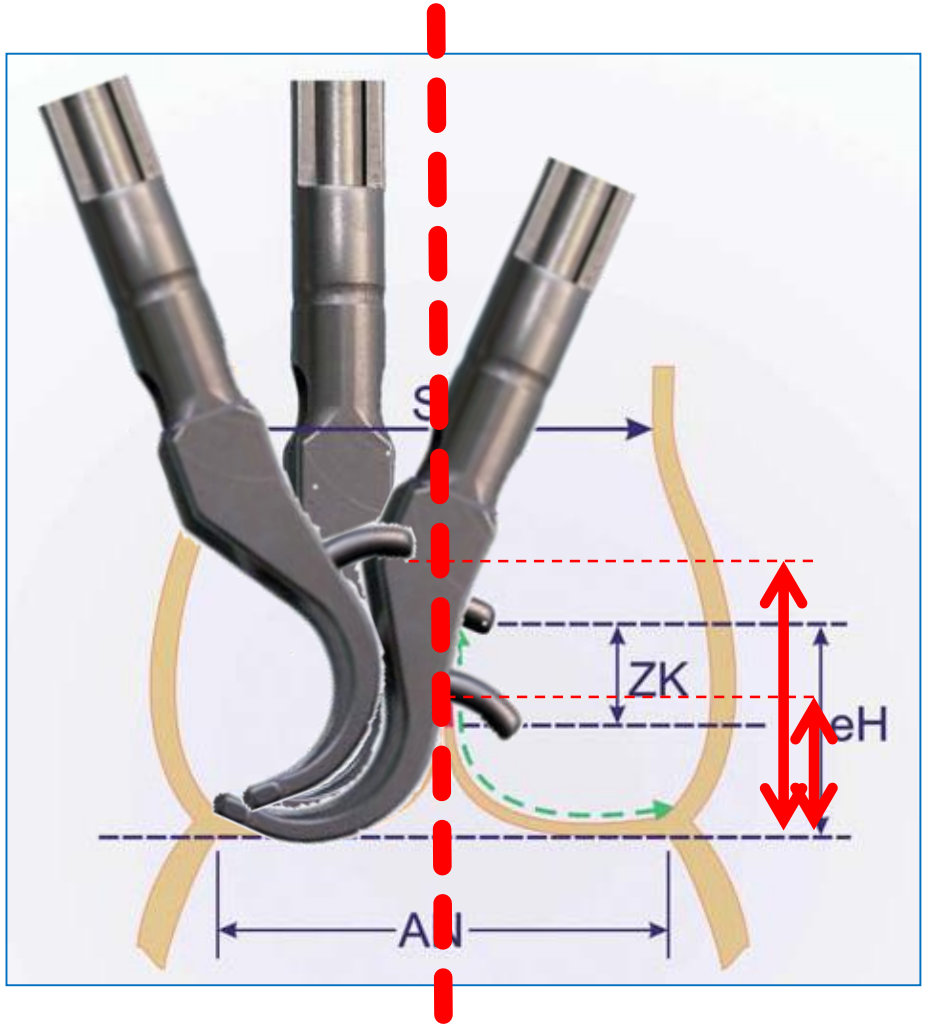




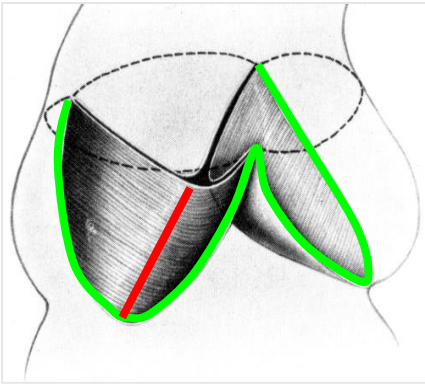
A new approach to the assessment of aortic cusp geometry

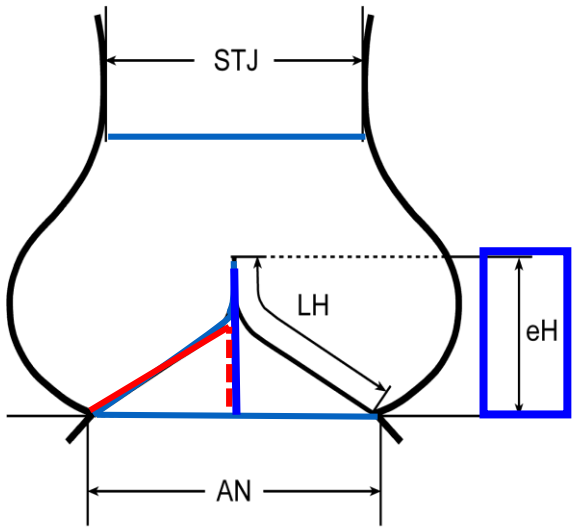
Hans-Joachim Schäfers, MD, PhD, Benjamin Bierbach, MD, and Diana Aicher, MD, Homburg/Saar, Germany

eH Measurement Error



Configurationof cusps





Cusp height in aortic valves

Hans-Joachim Schäfers, MD,[a] Wolfram Schmied, Dipl Psych,[a] Gil Marom, MSc,[b] and Diana Aicher, MD[a]

Objectives: Successful aortic valve repair must normalize cusp and root dimensions. Limited information is available on the normal dimensions of human cusps, in particular the cusp height.

Met
A tr
heig
anal

Res
± 2
valv
left
to 2
cusp
betw
degr

Con
corr
repa

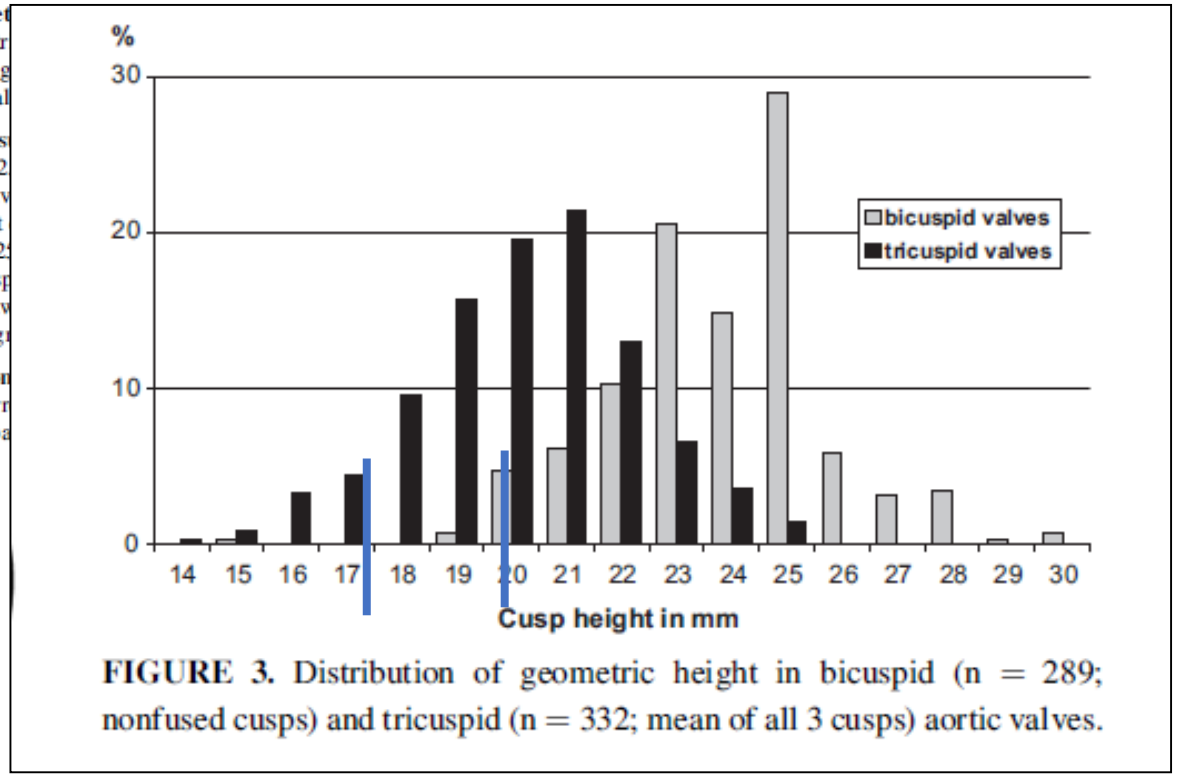
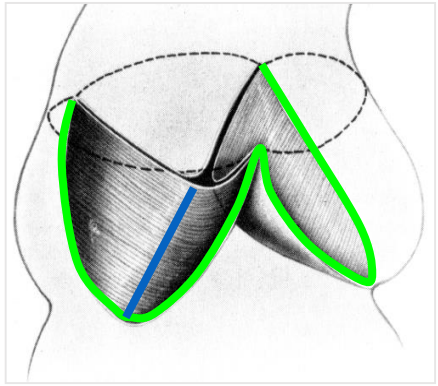
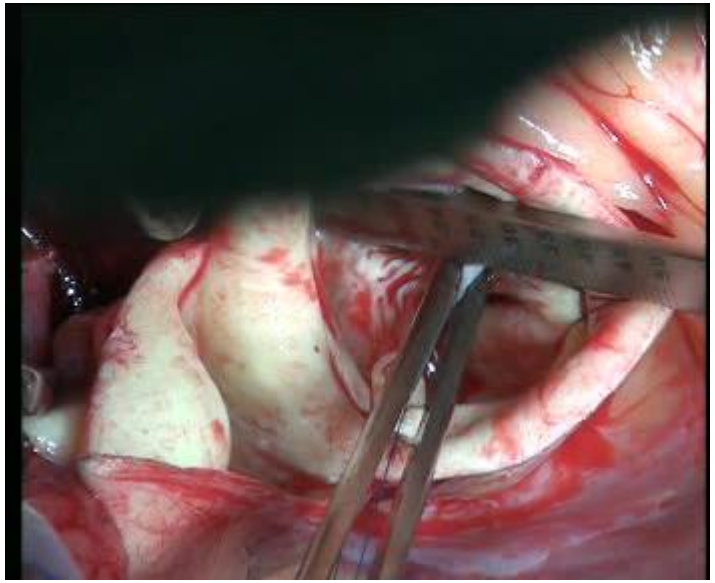


FIGURE 3. Distribution of geometric height in bicuspid (n = 289; nonfused cusps) and tricuspid (n = 332; mean of all 3 cusps) aortic valves.

Aortic Valve Repair - Assessment

Configuration/coaptation of cusps



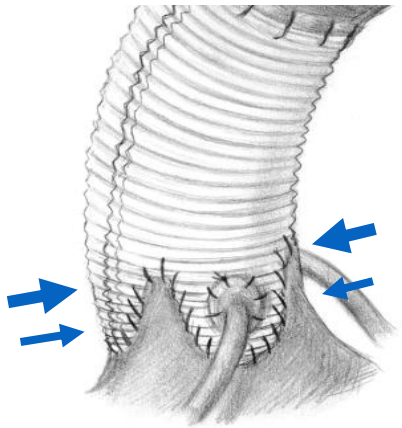


TAV: 17-22 mm

BAV: 20-25 mm

Root Correction

Root Remodeling



(Yacoub 1993)
(Sinus > 45 mm)

If

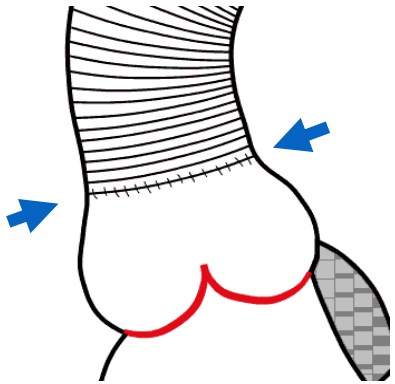
Sinus > 40 -45 mm

Root remodeling
(Valve reimplantation)

Sinus < 40-45 and STJ > 30-35 mm

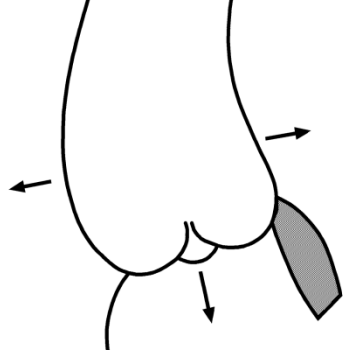
STJ remodeling

ST Junction Remodelling

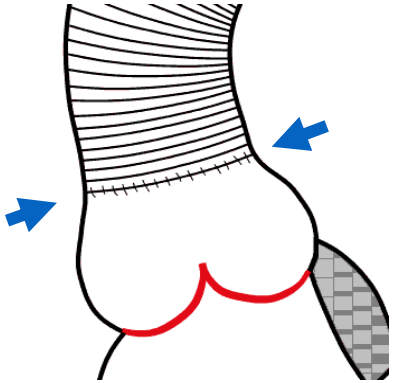


(Frater 1986)
(Sinus < 40-45 mm)

Root Repair – Technical Options

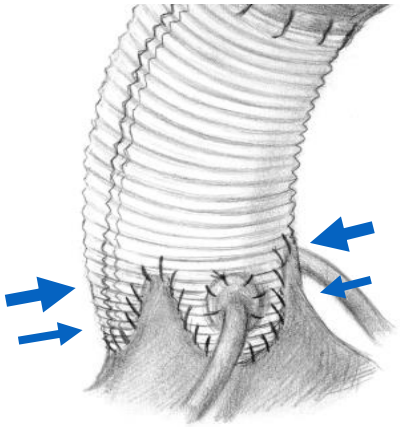


ST Junction Remodelling



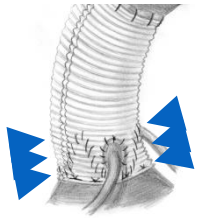
(Frater 1986)
(Sinus < 40-45 mm)

Root Remodeling



(Yacoub 1993)
(Sinus > 45 mm)

Reimplantation of Aortic Valve



(David 1992)
(AVJ ≥ 30 mm)

Valve Sparing: Our Routine

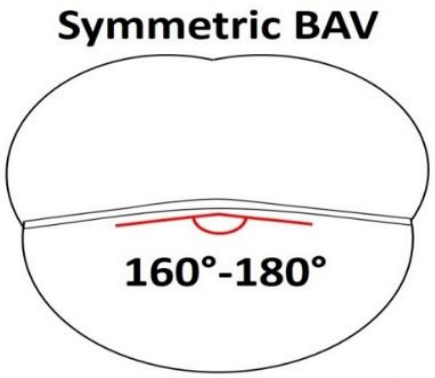
1. Measure gH and
   proceed with VPS if
   gH ≥ 18 mm

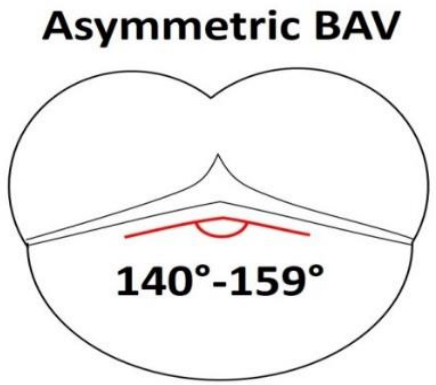
2. (Root remodeling) Take graft according to patient size

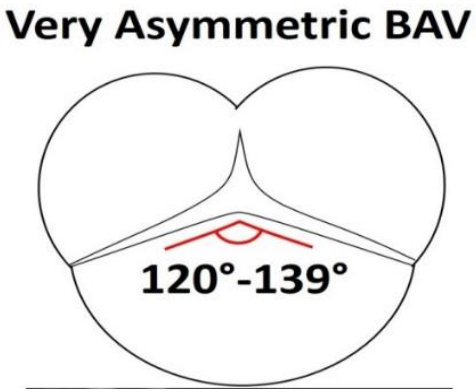
BSA	< 1.8 m²	24 mm
	1.8 to 2.2 m²	26 mm
	>2.2 m²	28 mm (?)

if gH ≤ 20 mm consider graft 1 size less

Commissural Orientation of BAV







40%
A

40%
B

20%
C

Keep/make symmetric BAV

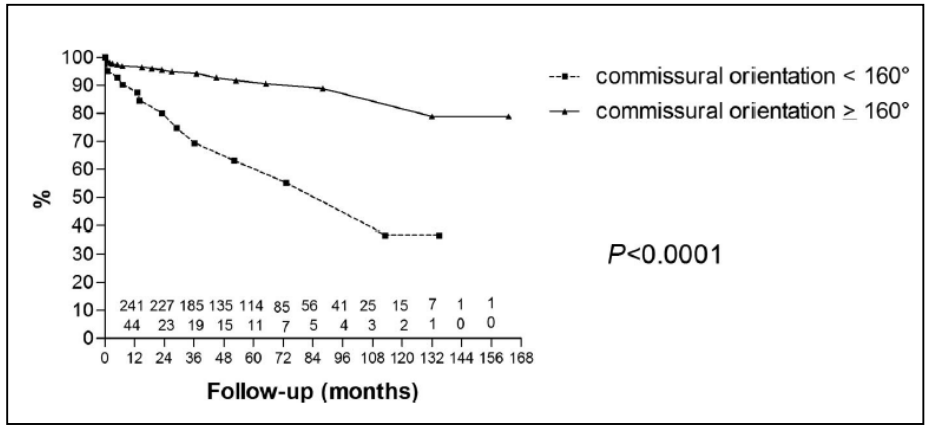
Make/treat as TAV

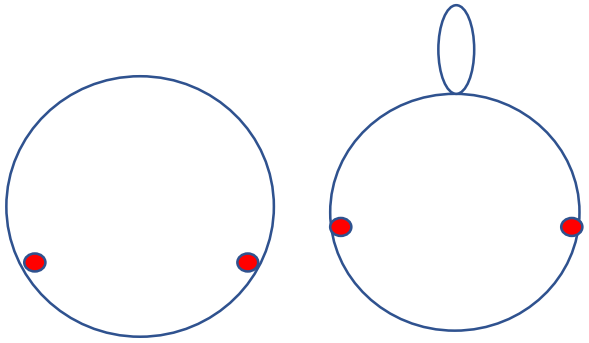
De Kerchove et al., AATS 2018

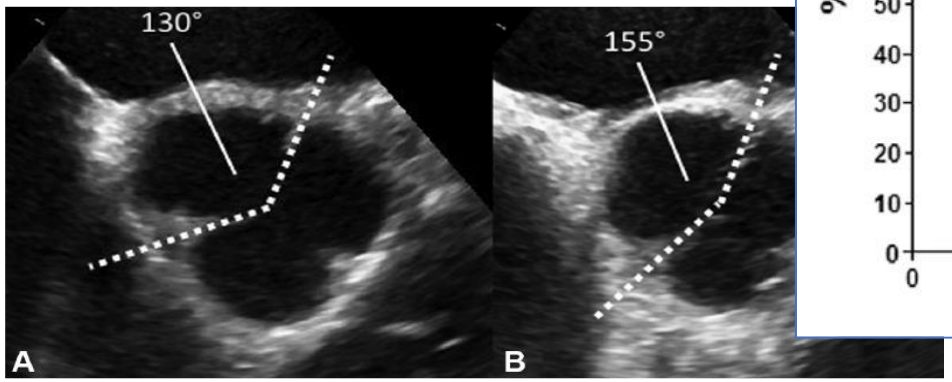
Sinus Plication to Improve Valve Configuration in Bicuspid Aortic Valve Repair—Early Results

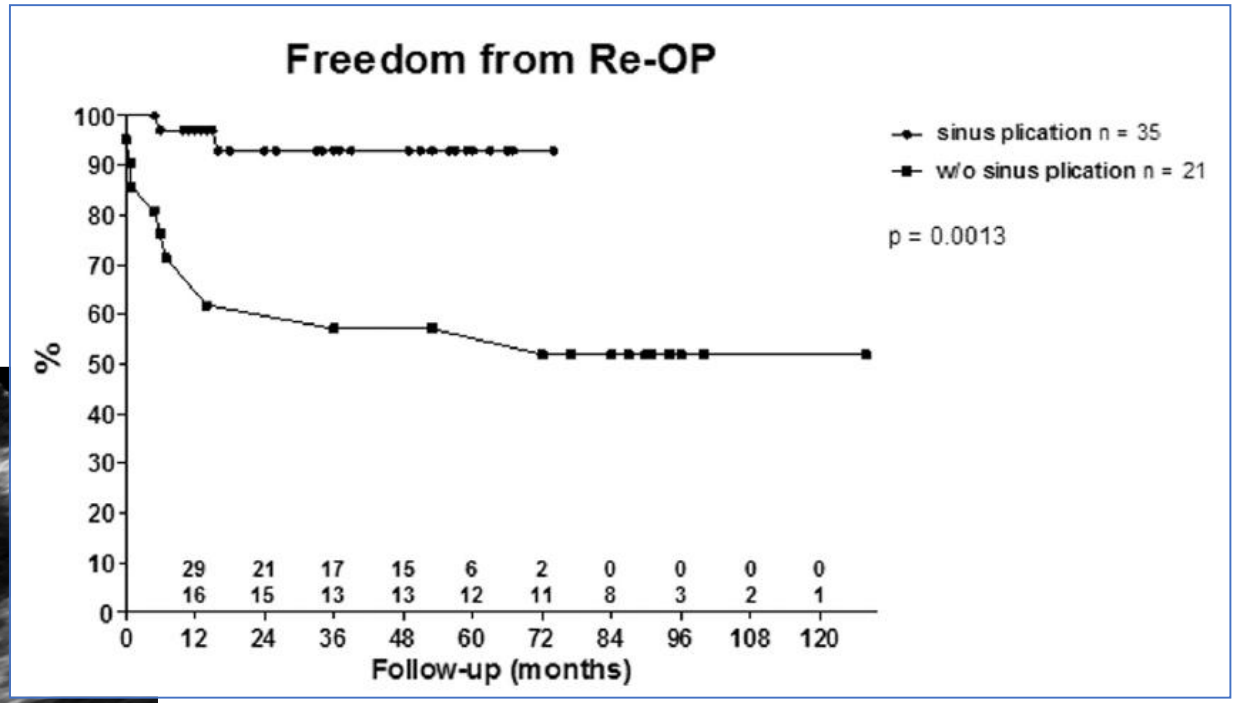
Ulrich Schneider, MD, Wolfram Schmied, Dipl-Psych, Diana Aicher, MD, Christian Giebels, MD, Lena Winter, MD, and Hans-Joachim Schäfers, MD

(Ann Thorac Surg 2017;103:580–6)



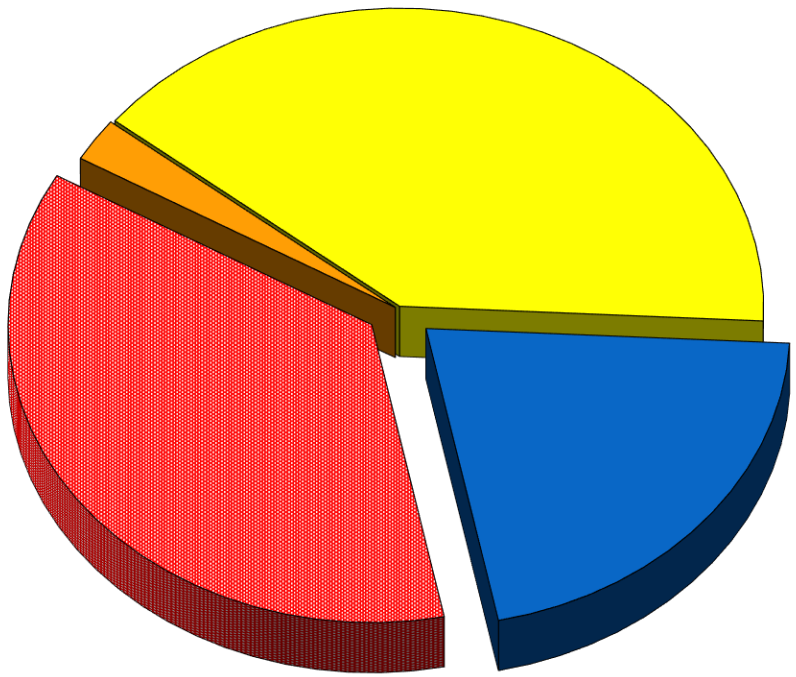






At discharge the mean peak transvalvular gradient in the study group was 14.3 ± 6.5 mm Hg, and it was 28.9 ± 18.5 mm Hg in the control group ($p = 0.003$).

AV Repair (n=2824)



Cusp Correction

If

- prolapse (eH ≤ 8 mm)
- structural defect
- anatomical variant

Plication of free margin / triangular resection

Patch correction

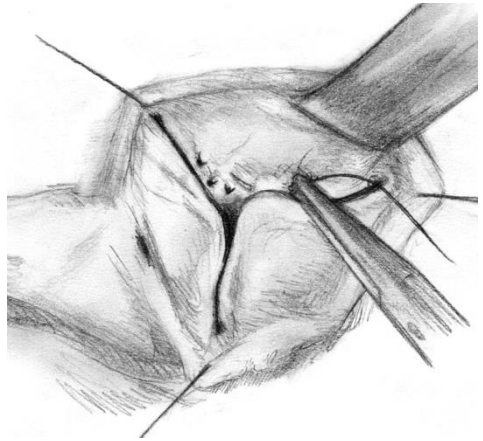
Conversion of anatomy (BAV, TAV constant)

- UAV ► BAV
- QAV ► TAV

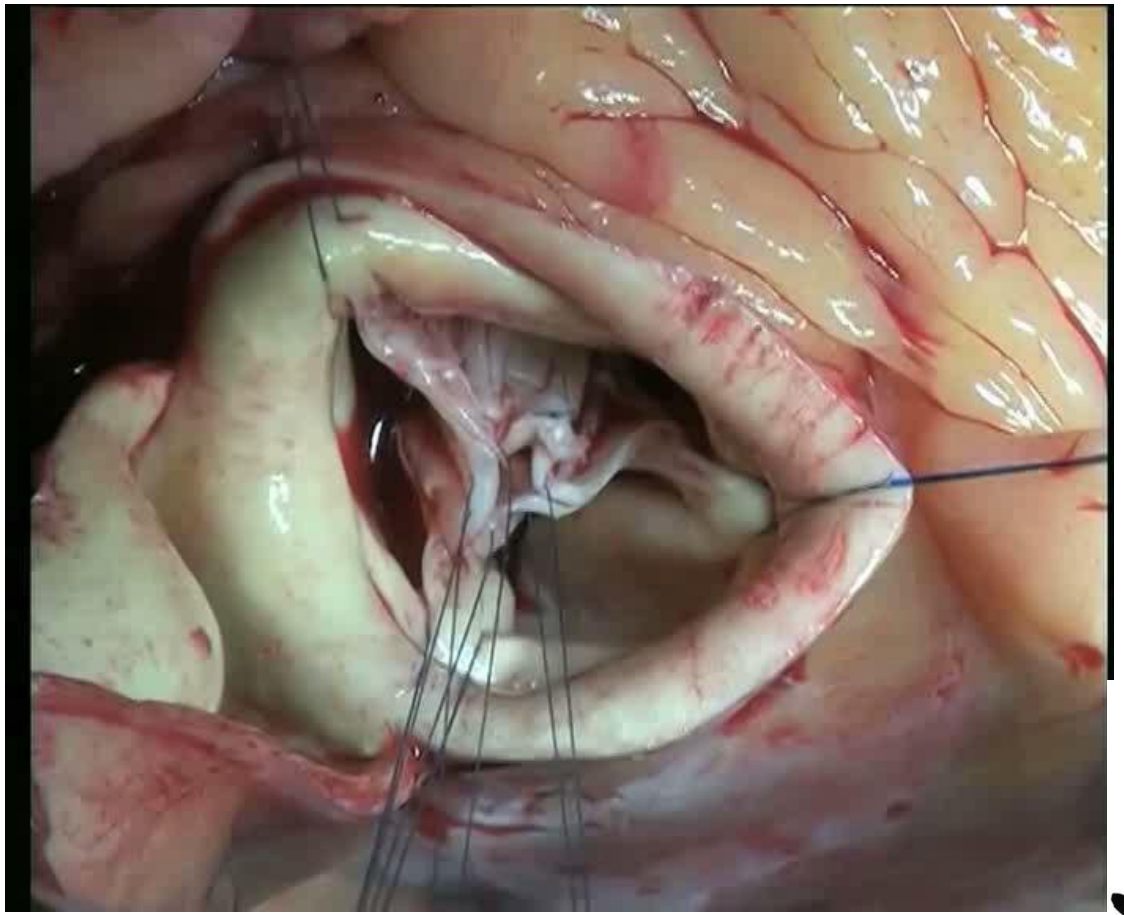
Reconstructive Techniques

Prolapse

Prolapse



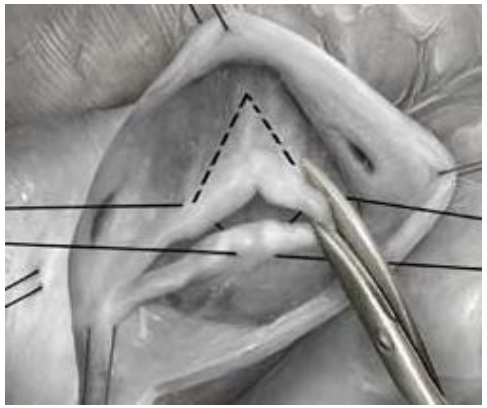
Plication of
Cusp Margin



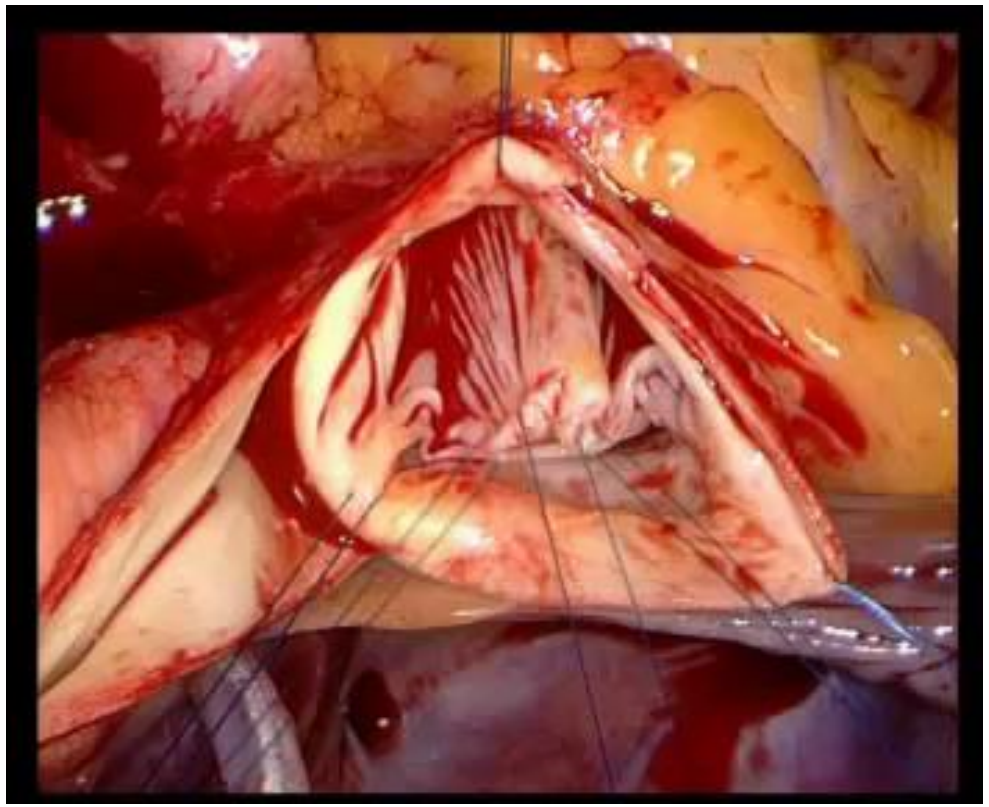
Reconstructive Techniques

Cusp Pathology

Fibrosis,
Calcium,
Redundancy

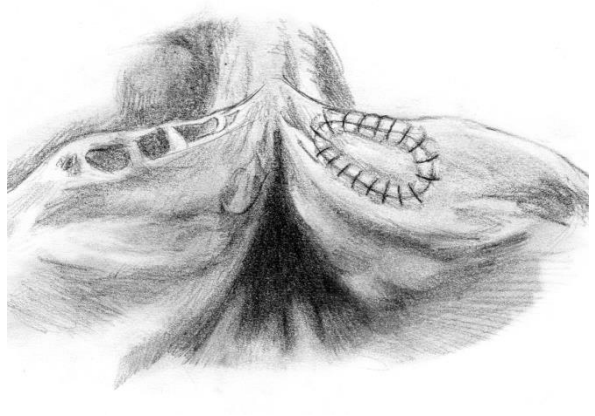


Triangular
Resection

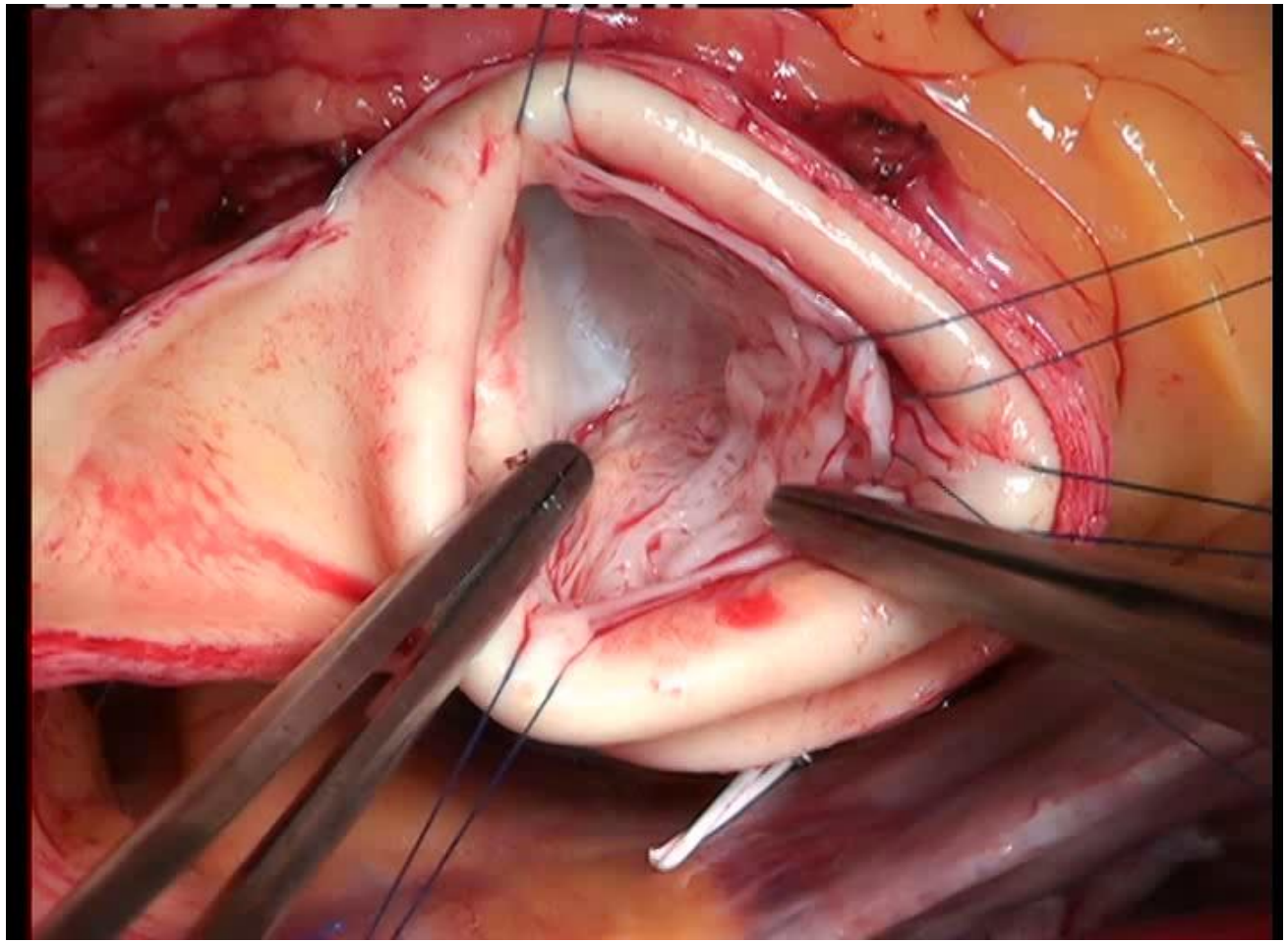


Reconstructive Techniques

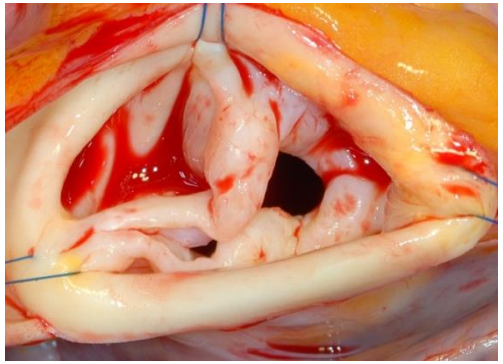
Fenestration

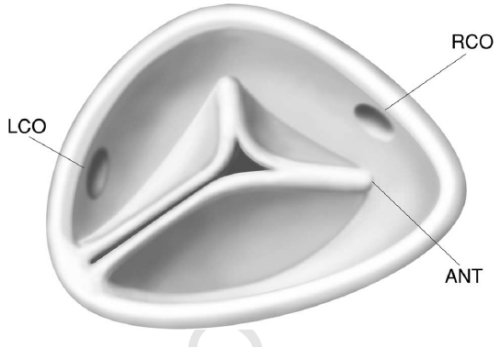


Stabilisation of
cusp (pericardium)

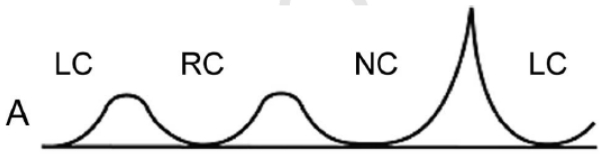


Bicuspidization of the Unicuspid Aortic Valve

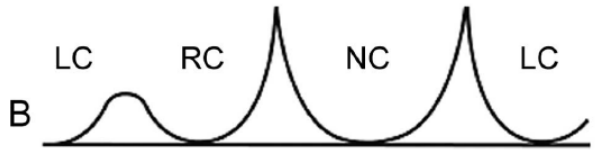




unicuspid



bicuspid



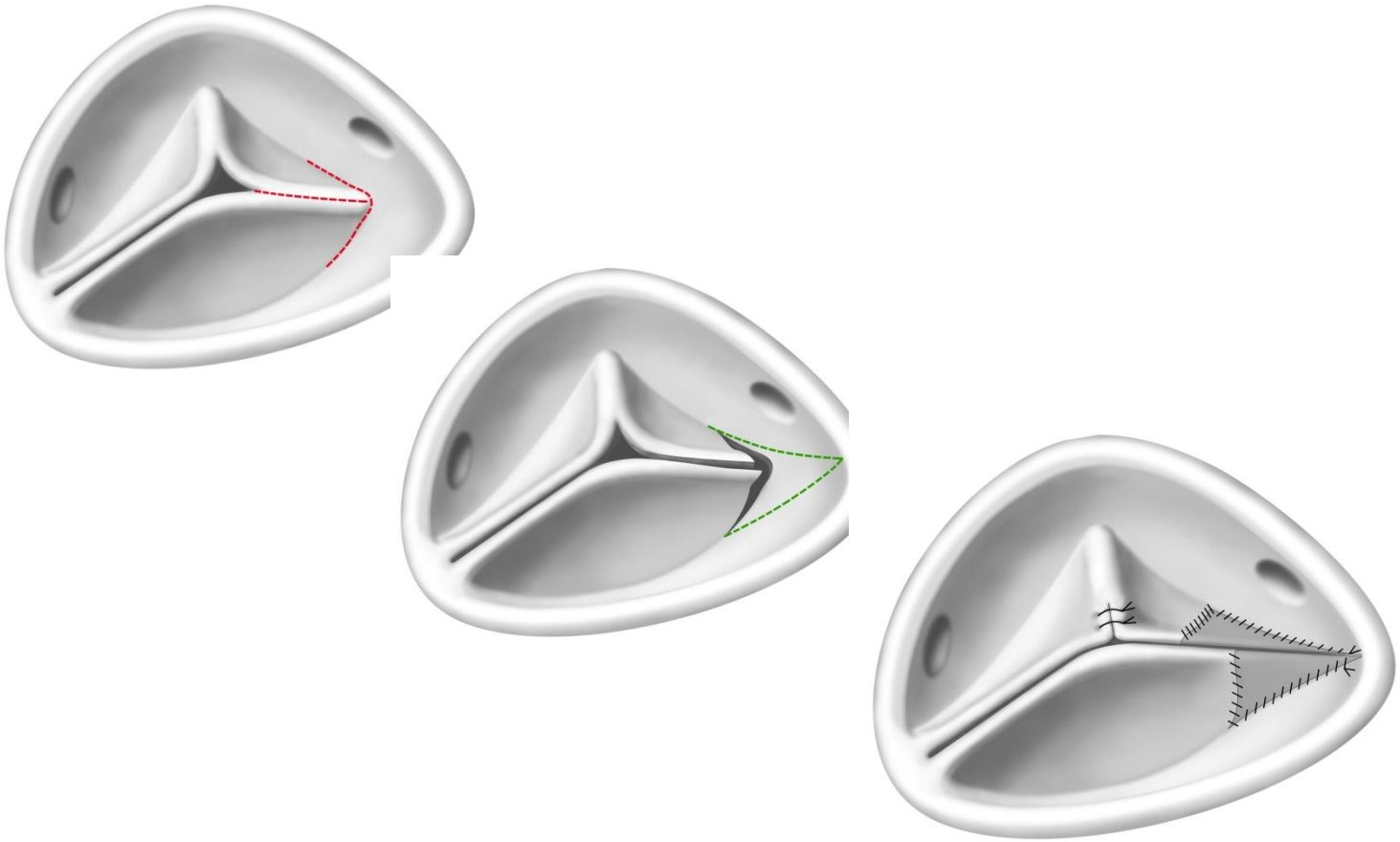
Anderson RA, JHVD 2001

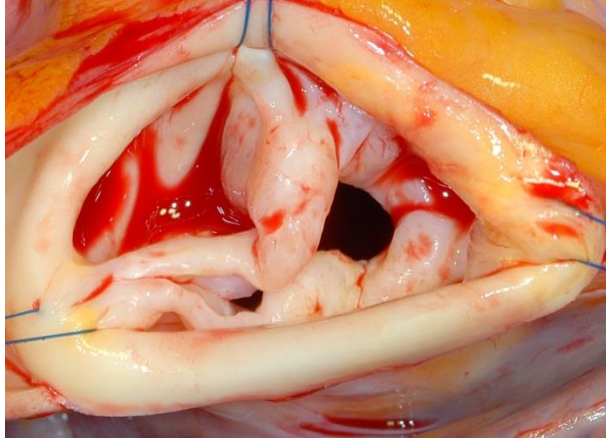
Aortic Valve Anatomy

Morphology	Incidence	Mean Age of Failure
Unicuspid	< 1%	20s
Bicuspid	2%	60s
Tricuspid	97 %(?)	?
Quadricuspid	< 1 %	40s

Roberts WC, Circulation 2005

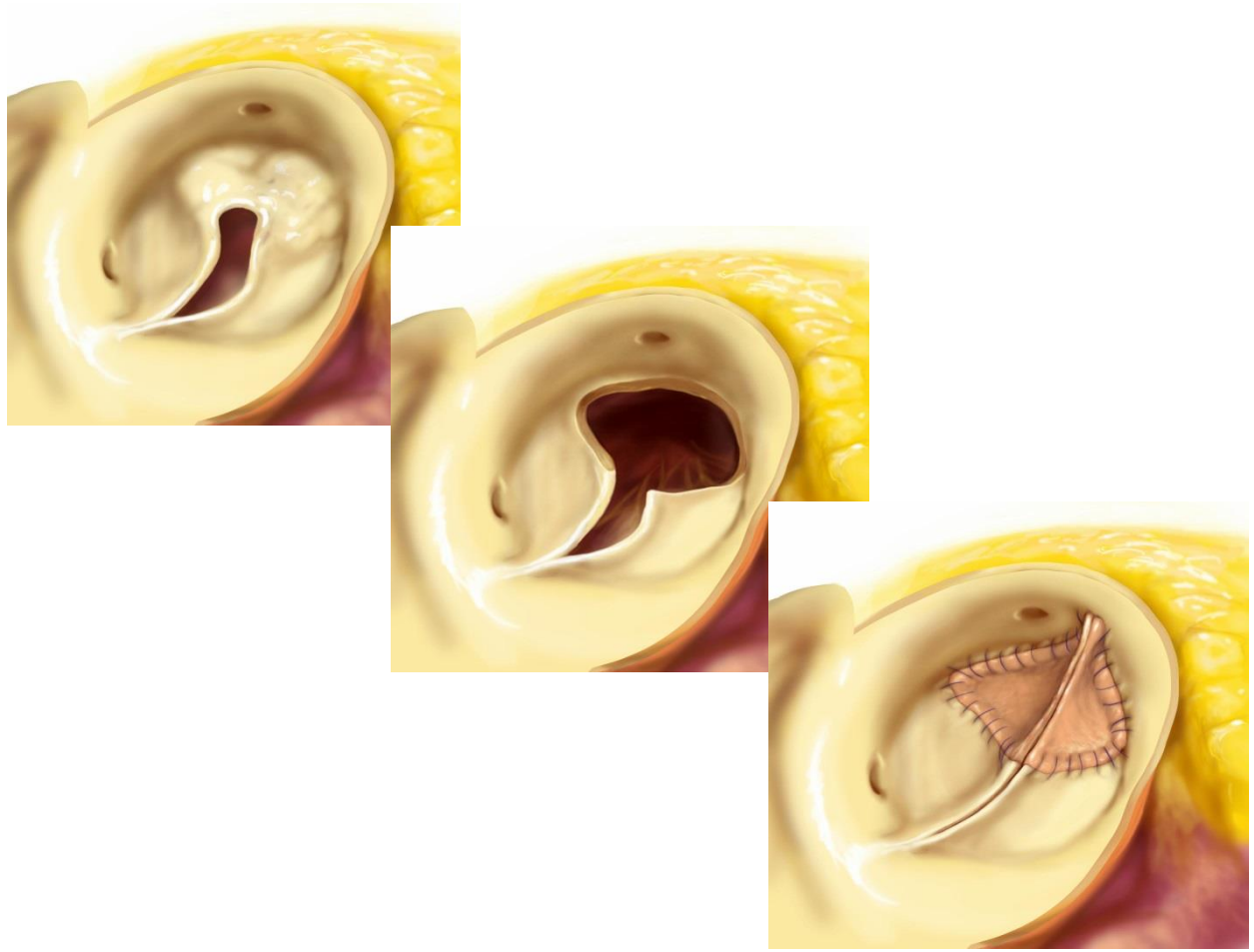
Bicuspidization of the Unicuspid Aortic Valve

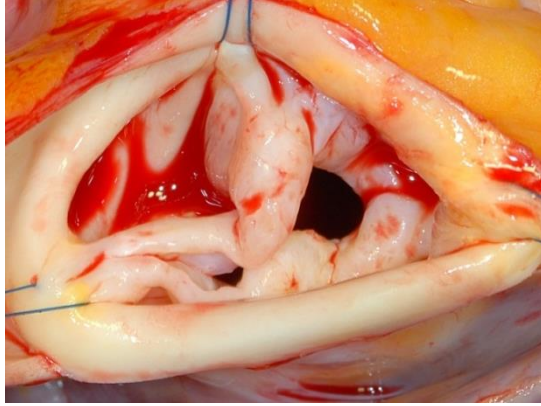




Schäfers HJ, ATS 2008

Bicuspidization of the Unicuspid Aortic Valve II

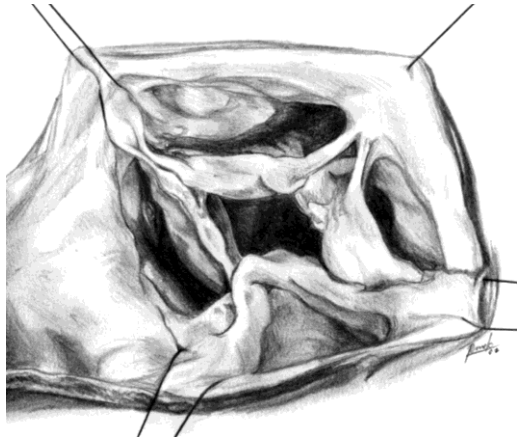




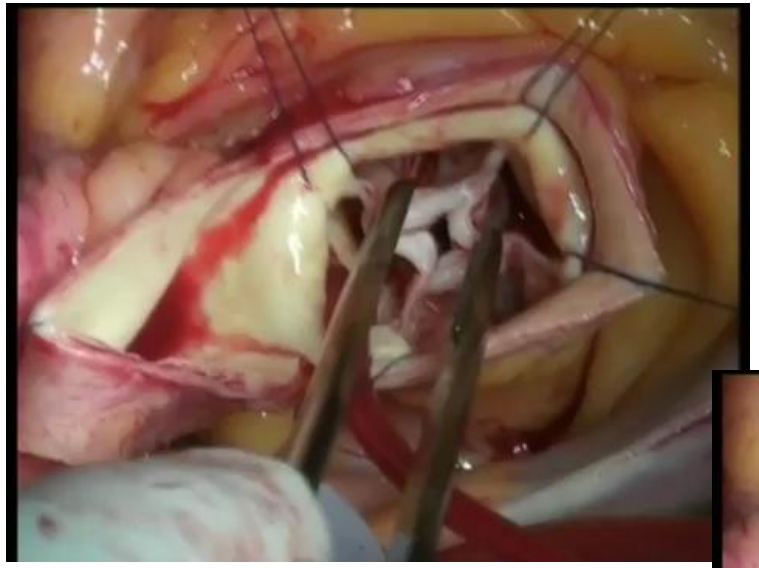
Reconstructive Techniques

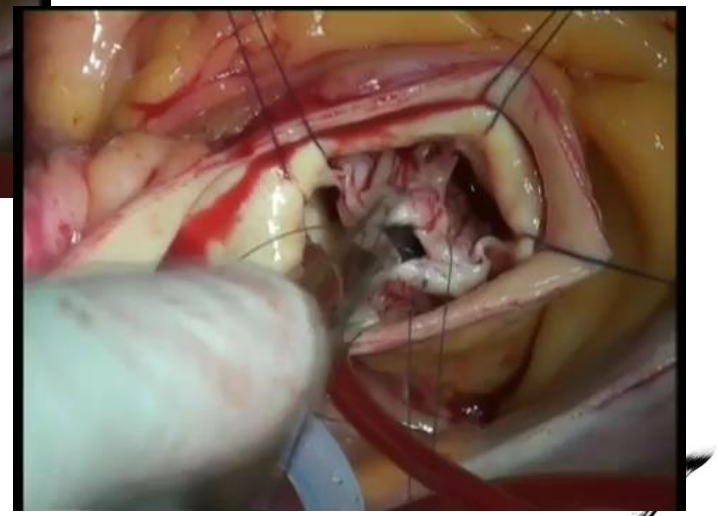
Cusp Pathology

Anomaly



Conversion of configuration





Schmidt et al., Ann Thorac Surg 2007

Annuloplasty

If

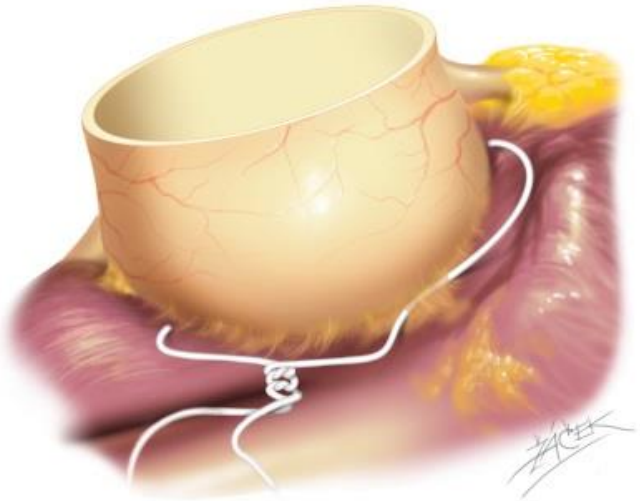
Basal diameter > 26-27 mm

Annular reduction

- ► 25 mm for BSA > 2 m²
- ► 23 mm for BSA < 2 m²

Reduce by 2 mm for

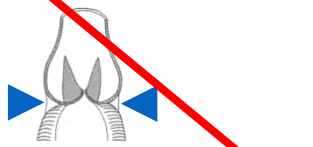
gH < 19 (TAV) / 22 (BAV) mm



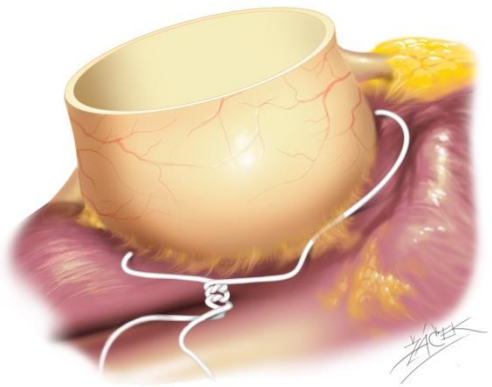
Repair – Technical Options

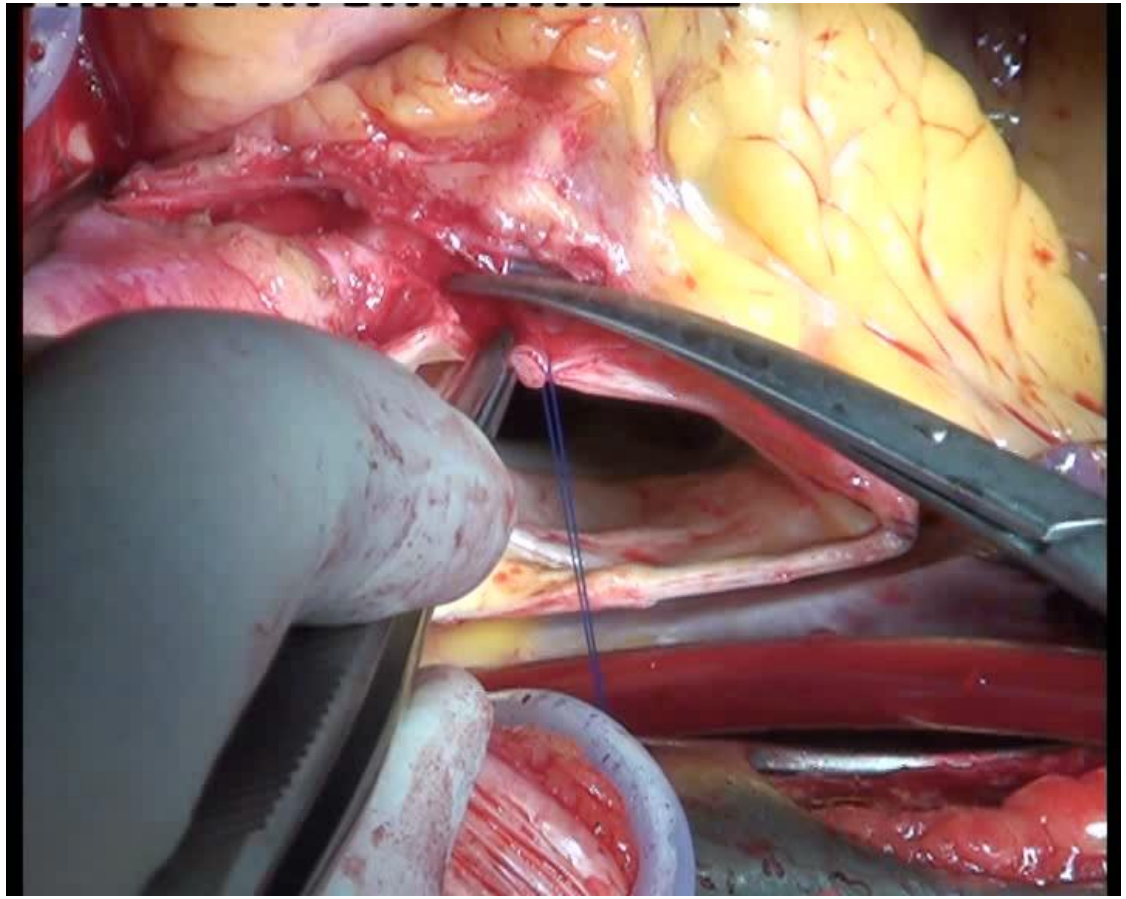
Annular Stabilisation
(AVJ > 25 – 27 mm)

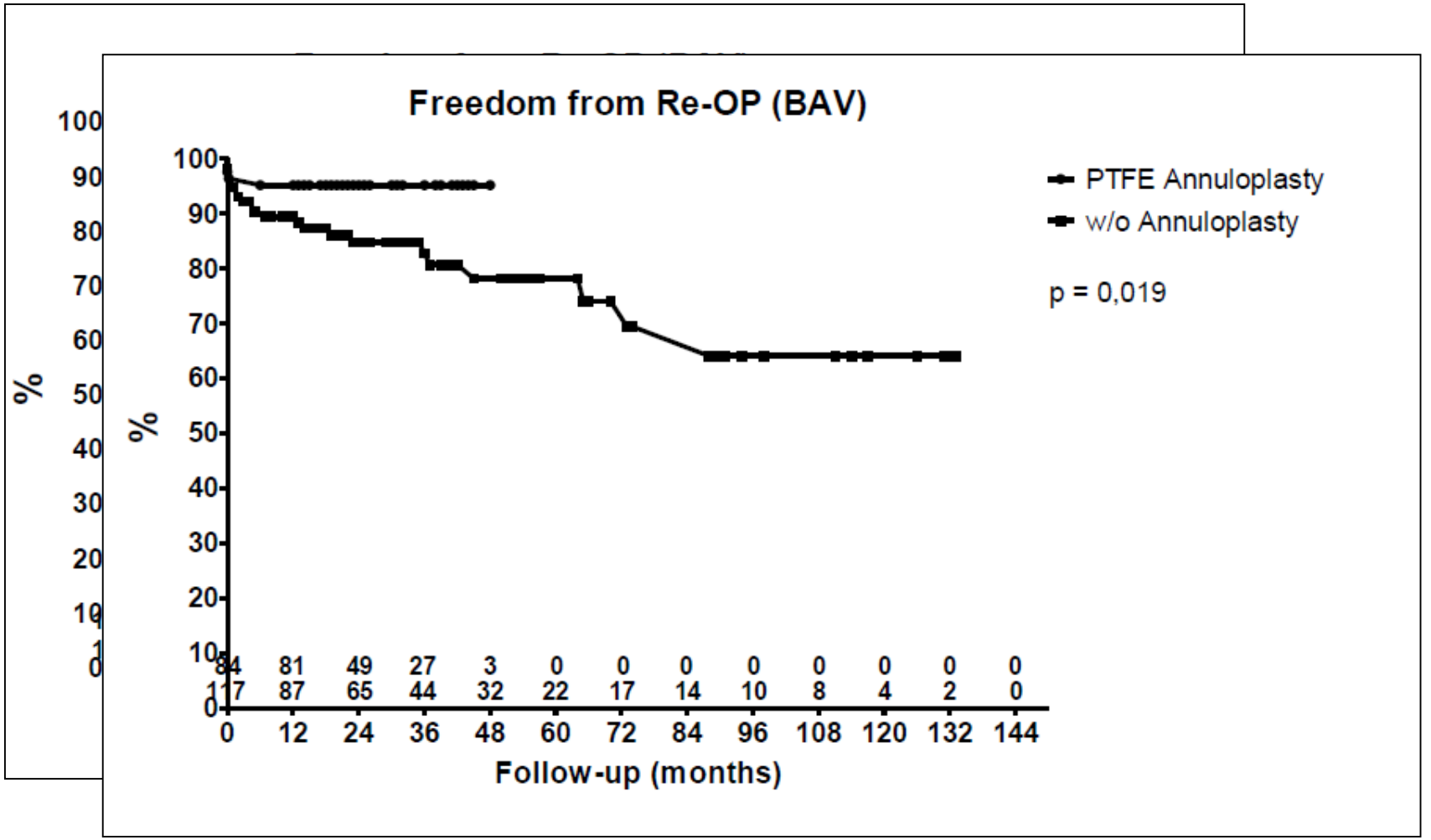
Subcommissural Plication



(Cabrol 1966)






Freedom from Re-OP (BAV)
%
100
90
80
70
60
50
40
30
20
10
0
PTFE Annuloplasty
w/o Annuloplasty
p = 0,019
84 81 49 27 3 0 0 0 0 0 0 0 0
117 87 65 44 32 22 17 14 10 8 4 2 0
0 12 24 36 48 60 72 84 96 108 120 132 144
Follow-up (months)

Standardized Aortic Valve Repair

1. No relevant calcification,
   geometric cusp height > 17-20 mm

<u>Decision for valve preservation</u>

2. Sinus diameter > 40 -45 mm
   (and /or BAV < 150° ?)

<u>Root replacement</u>

Standardized Aortic Valve Repair

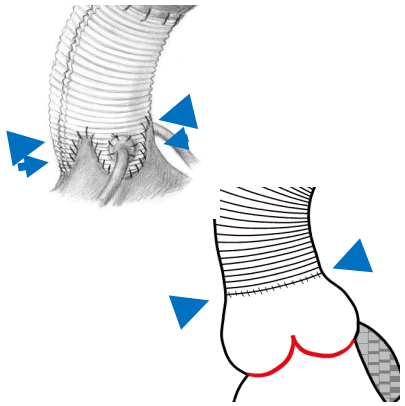
3. If root + cusp necessary,

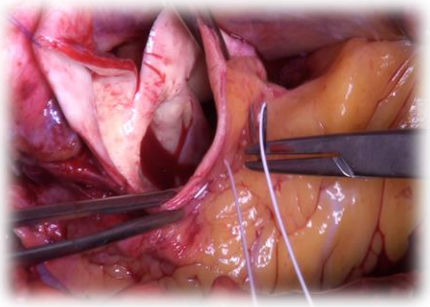
Root repair first (interaction between intercommissural distance and cusp configuration)

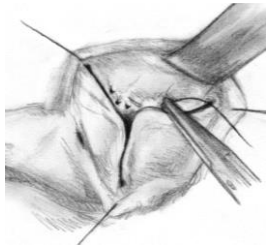
4. Annular stabilization (AI, durability)

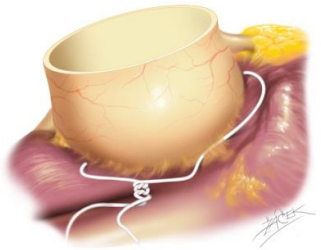
5. Correction of cusp prolapse (eH)

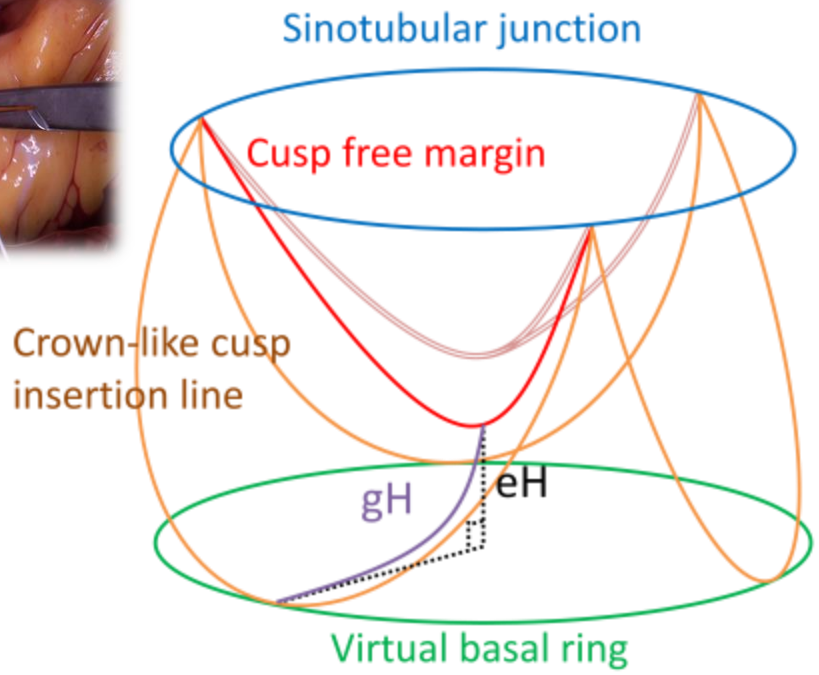
Management of Valve/Cusp Configuration









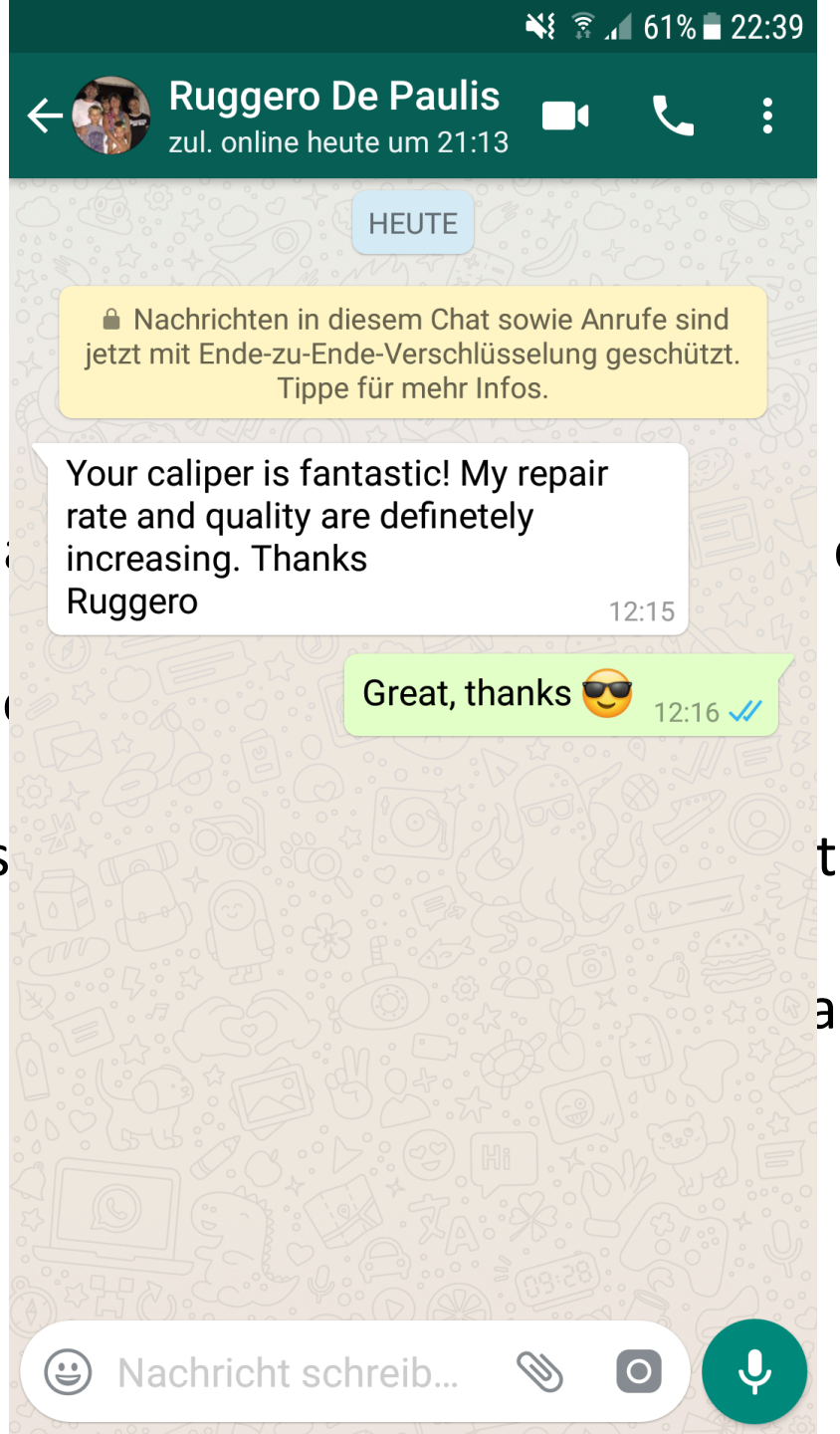


Root Remodeling
STJ Remodeling
External Suture STJ-Plasty

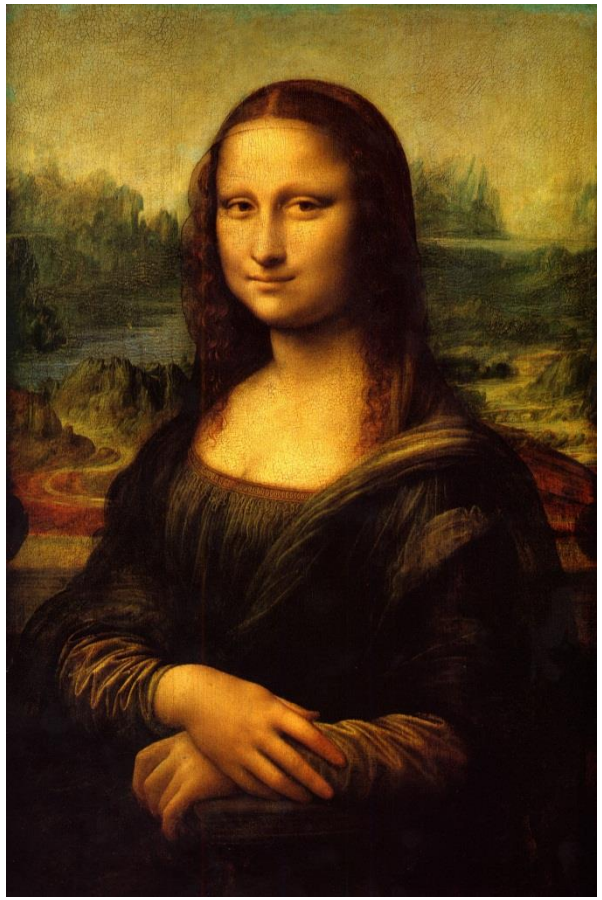
Cusp Margin Plication

External Suture Annuloplasty

- Systematic ana components
- Many strategi
- Normalize cus t)!
- Specific valve approach



Aortic Valve Reconstruction



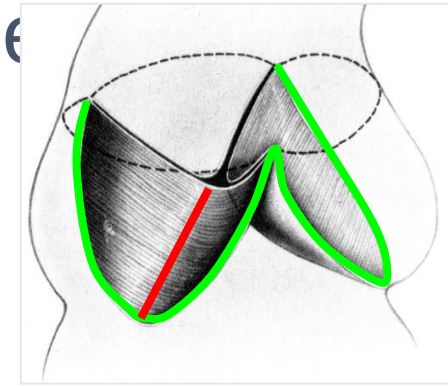

Thank you for your attention

If you are interested in more details….

www.care-saar.com/en

https://www.care-saar.com/c/produkte/aortic-valve-repair-principles-and-techniques-a-vi

Aortic Valve Repair - Assessme



Solutions

Configuration/coaptation of cusps

Cusp height in aortic valve

Hans-Joachim Schäfers, MD,[a] Wolfram S

Objectives: Successful aortic valve rep
available on the normal dimensions of

Methods: The cusp height was measure
A tricuspid anatomy was present in 329
height, weight, preoperative degree of a
analyzed for possible interrelation betw

Results: In the bicuspid valves, the geon
± 2.0). Significant correlations were fo
valves, the height of the noncoronary c
left coronary cusp varied from 12 to 25
to 25 mm (mean, 20.0 ± 2.1). The nonco
cusp ($P = .000$). No difference was fou
between the geometric height and clini
degree of aortic regurgitation.

Conclusions: We found the cusp height
correlates with the clinical variables. T
repair. (J Thorac Cardiovasc Surg 2012;

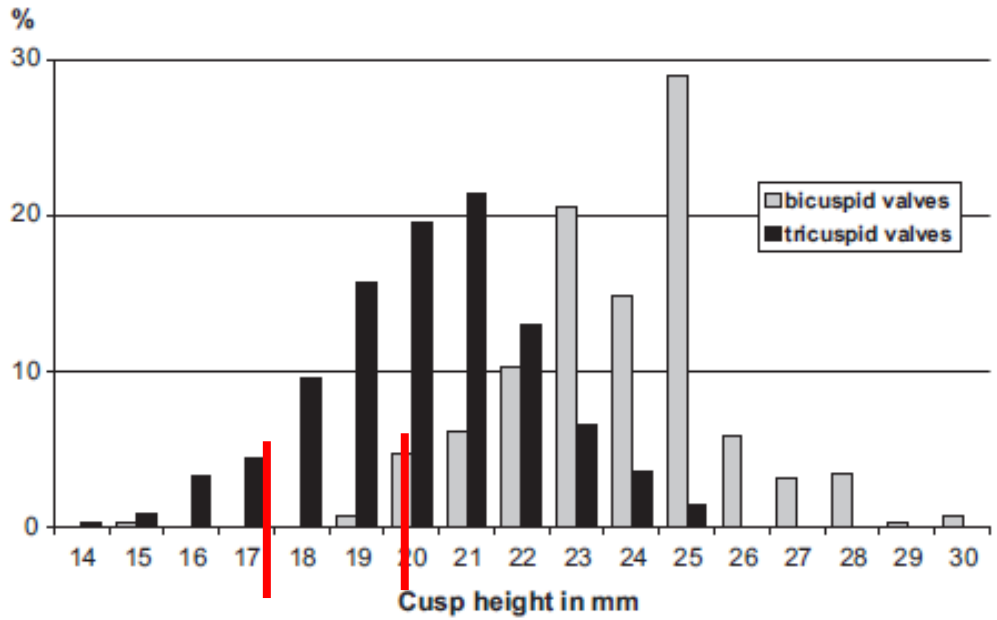


FIGURE 3. Distribution of geometric height in bicuspid (n = 289; nonfused cusps) and tricuspid (n = 332; mean of all 3 cusps) aortic valves.