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17.05.2017

# Aortic Valve Repair – a Modular and Geometric Approach

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

Title

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

**Objective:** Valve repair for aortic disease. Over time, repair is a strategy and can predict long-term valve repair.

**Methods:** From 1996 to 2016, 100 patients (mean age  $54 \pm 16$  years; 53 patients had type III (restrictive)

**Results:** In-hospital mortality was 10%. Functional class I and II were achieved in 47 [29–73] months (mean  $95 \pm 3\%$ ). Ten patients died from AV regurgitation (9%;  $93 \pm 5\%$ ) or

**Conclusion:** Aortic insufficiency functional classification is an important

## 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 restriction due to aortic dilatation and restriction due to cusp degeneration/retraction

# Causes of Aortic Regurgitation

## 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

Ac  
Aoi  
Cc  
My  
Rh  
Inf  
Ca

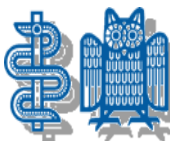
**Background**—Reconstruction of the aortic valve for aortic regurgitation (AR) remains challenging, in part because of not only cusp or root pathology but also a combination of both can be responsible for this valve dysfunction. We have systematically tailored the repair to the individual pathology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

Cusp pathology





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

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## Aortic root dilatation may alter the dimensions of the valve leaflets<sup>☆</sup>

Mano J. Thubrikar<sup>a</sup>, Michel R. Labrosse<sup>a,\*</sup>, Kenton J. Zehr<sup>a</sup>,  
Geoffrey G. Gong<sup>a</sup>, Brett L. Fowler<sup>a</sup>

<sup>a</sup>Heineman Medical Research Laboratory, Department of Thoracic and Cardiovascular Surgery, Carolinas Medical Center, Charlotte, NC, USA

<sup>b</sup>Division of Cardiovascular Surgery, Mayo Clinic, Rochester, MN, USA

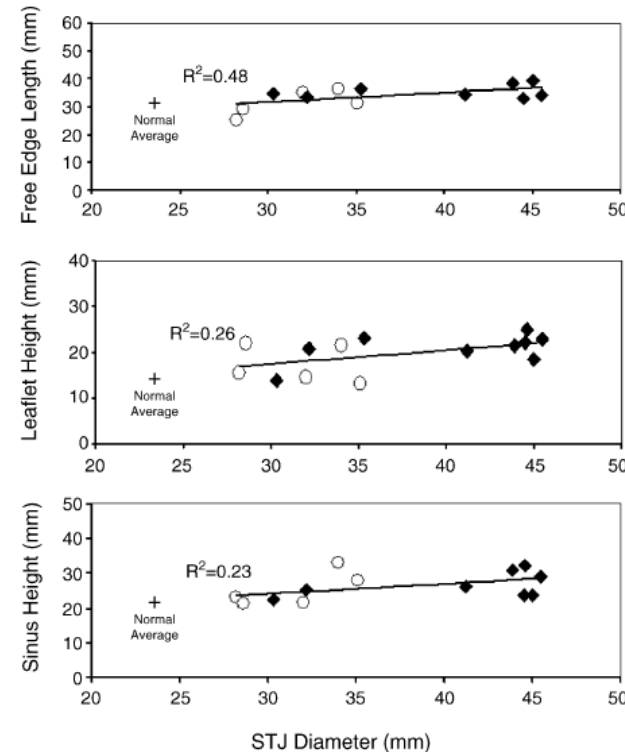
Received 22 June 2005; received in revised form 20 August 2005; accepted 18 September 2005

### Abstract

**Objective:** Valve-sparing surgery can be used in patients with dilated aortic roots and aortic insufficiency, in part because the spared valve may be incompetent. Our goal was to study how the dimensions of the valve leaflets changed in such patients. **Methods:** Fourteen patients with dilated aortic root and AI were examined. We measured annulus diameter, sinotubular junction (STJ) diameter, sinus height, leaflet free-edge length, and leaflet height, and among these dimensions and with the AI grades were explored. Measurements were also made in normal hearts. **Results:** There was no evident change in the average diameter of the annulus between the normal and dilated aortic roots. The STJ diameter was obviously increased in the dilated aortic roots; the aortic sinuses also were dilated. The leaflet free-edge length, the leaflet height, and the sinus height were found to increase with the degree of AI. The degree of AI was not found to correlate well with any of the dimensions measured. **Conclusions:** Dilatation of the aortic root is parallel to aortic root dilatation with AI. Therefore, during valve sparing, it may be necessary to tailor the leaflet free-edge length to achieve a competent valve.

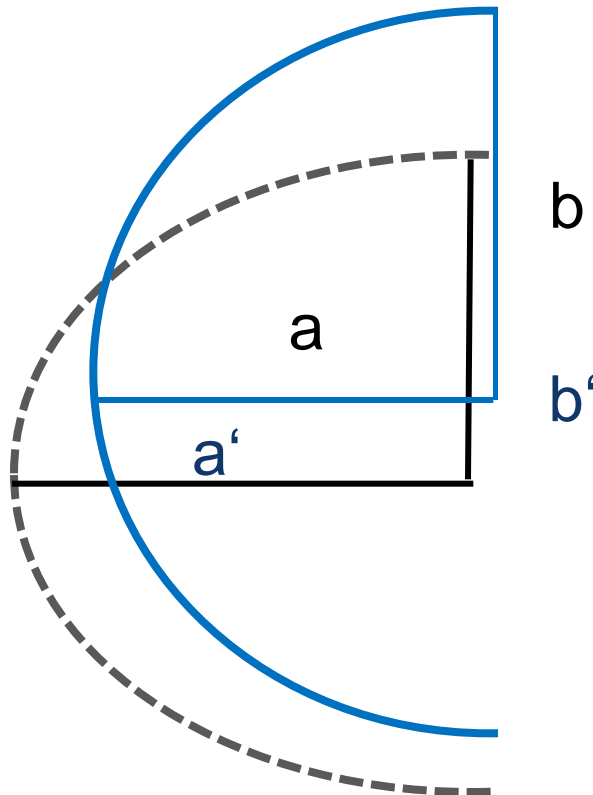
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**Keywords:** Aortic valve; Aortic root; Leaflets; Dimensions; Aneurysm; Insufficiency



# Reduction of STJ and Cusp Prolapse

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)



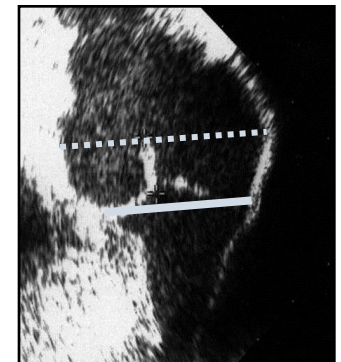
$$C_E = \pi \times [3/2 \times (a+b) - \sqrt{a \times b}]$$

$$b \approx r_{\text{aorta}}$$

$$a \approx r_{\text{cusp}}$$



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



# Standardized Aortic Valve Repair

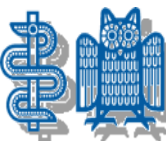
1. Assessment

Root pathology

2. Correction



Valve morphology  
Cusp pathology



# 1. Root Assessment

## Echo:

Maximum sinus diameter ► >40 / 45 mm?

ST diameter ► >35 (?)

Annular diameter (?)

## Intraoperative:

Annular diameter (!) ► >25 / 28 mm?

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

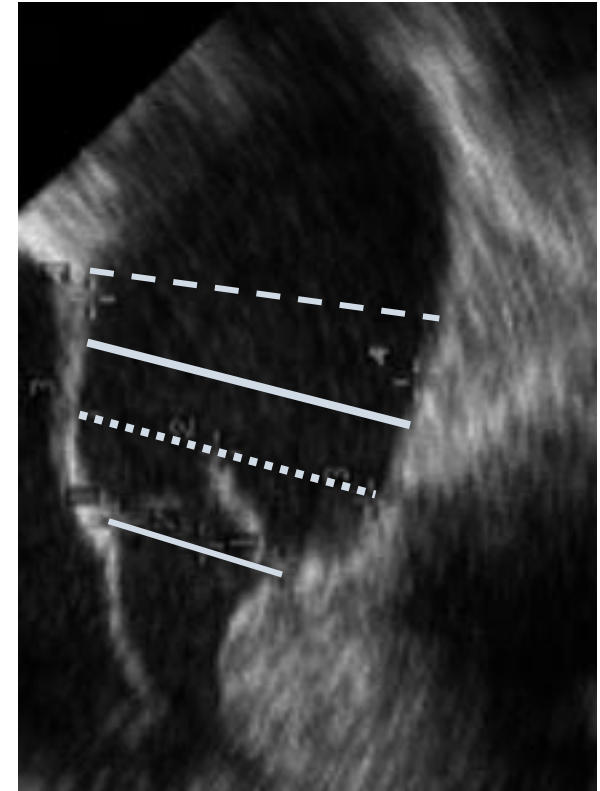
# AI und TTE/TEE

Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?





## 2. Cusp Assessment

### **Echo:**

Valve morphology?  
Eccentricity of jet?

### **Intraoperative:**

Valve Morphology?  
Cusp height/configuration?  
Cusp substance?

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

# AI und TTE/TEE

Root dimensions

AV morphology  
(uni-,bi-/tricuspid)

Prolapse

Calcification?



Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

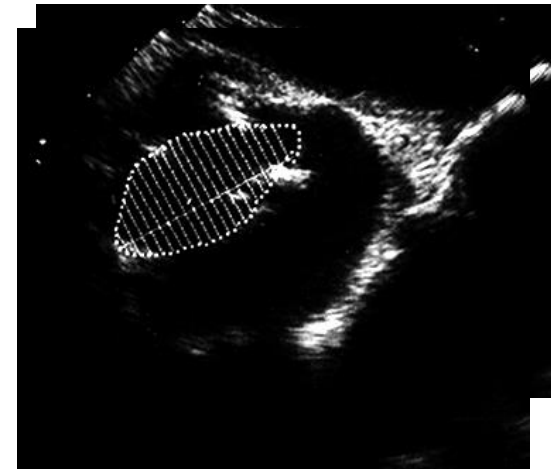
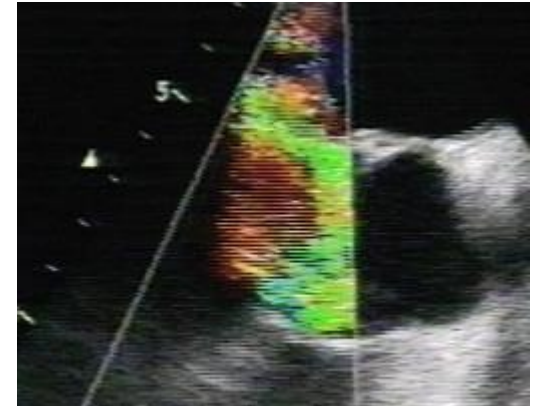
# AI und TTE/TEE

Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?



# Intraoperative Cusp Assessment

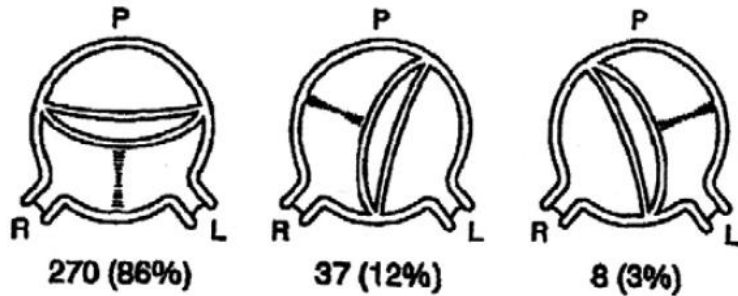
- ➔ Morphology (commissural height):
  - Unicuspid
  - Bicuspid
  - Tricuspid
  - Quadricuspid
- If non-tricuspid, watch for anatomical variation
  
- ➔ Prolapse?
- ➔ Retraction?

# Bicuspid Aortic Valve (BAV)

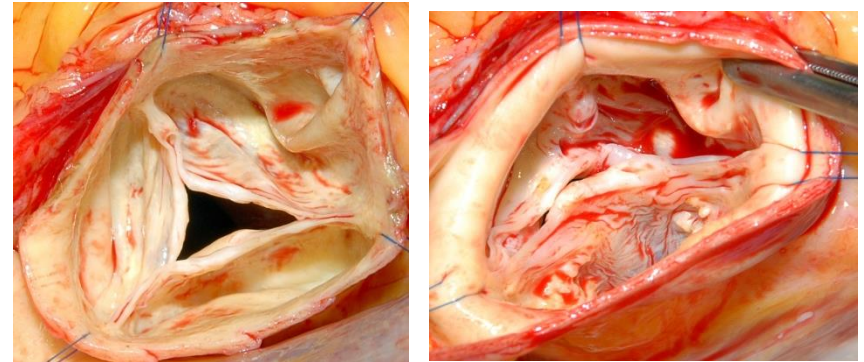
Titel des Vortrags und Verfasser (bitte in Folienmaster anpassen)

## Morphology

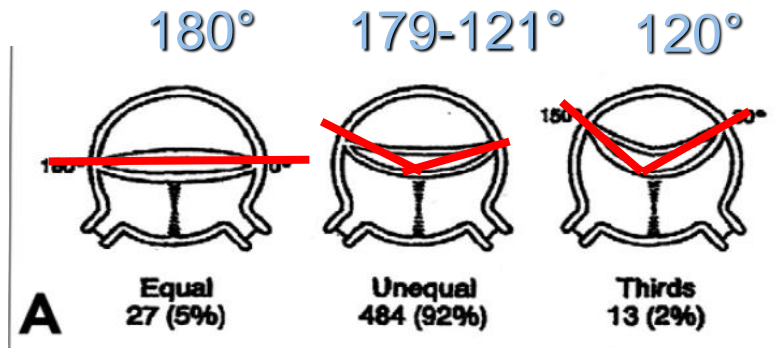
pattern of fusion



degree of fusion



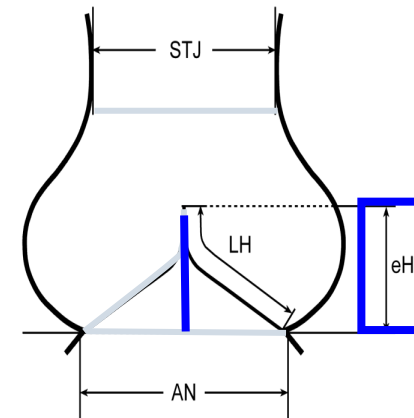
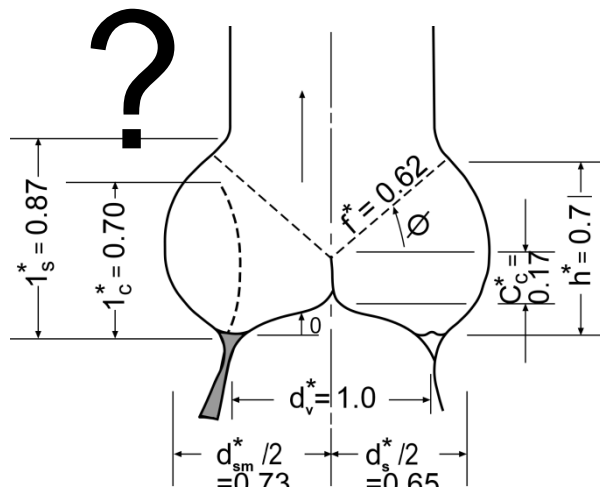
commissural  
orientation



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

# Aortic Valve Repair - Assessment

## Configuration of cusps



Swanson, Circ Res 1974

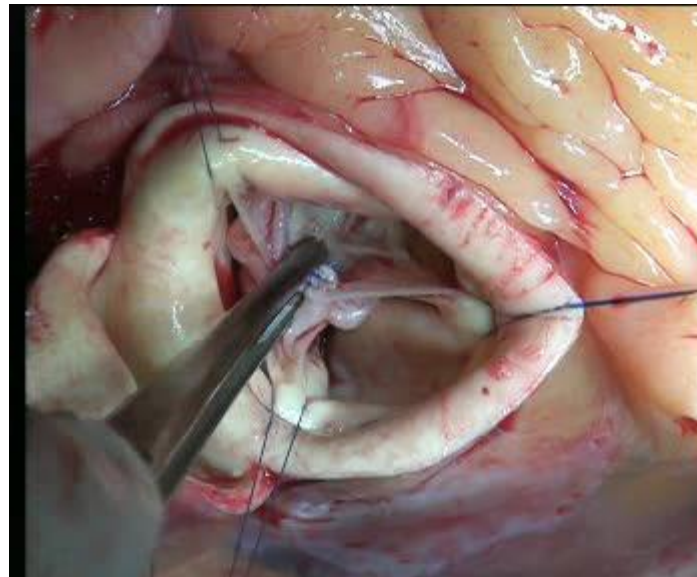
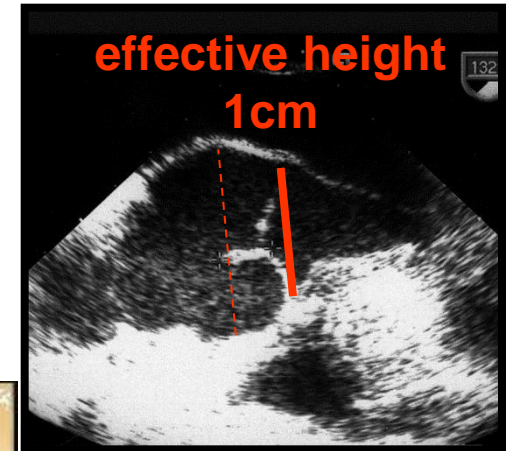
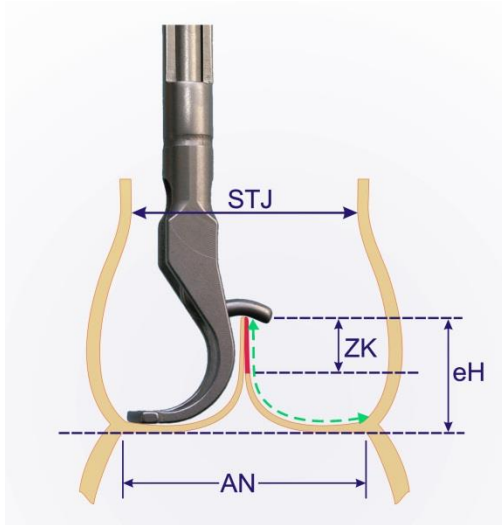
**A new approach to the assessment of aortic cusp geometry**

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



Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

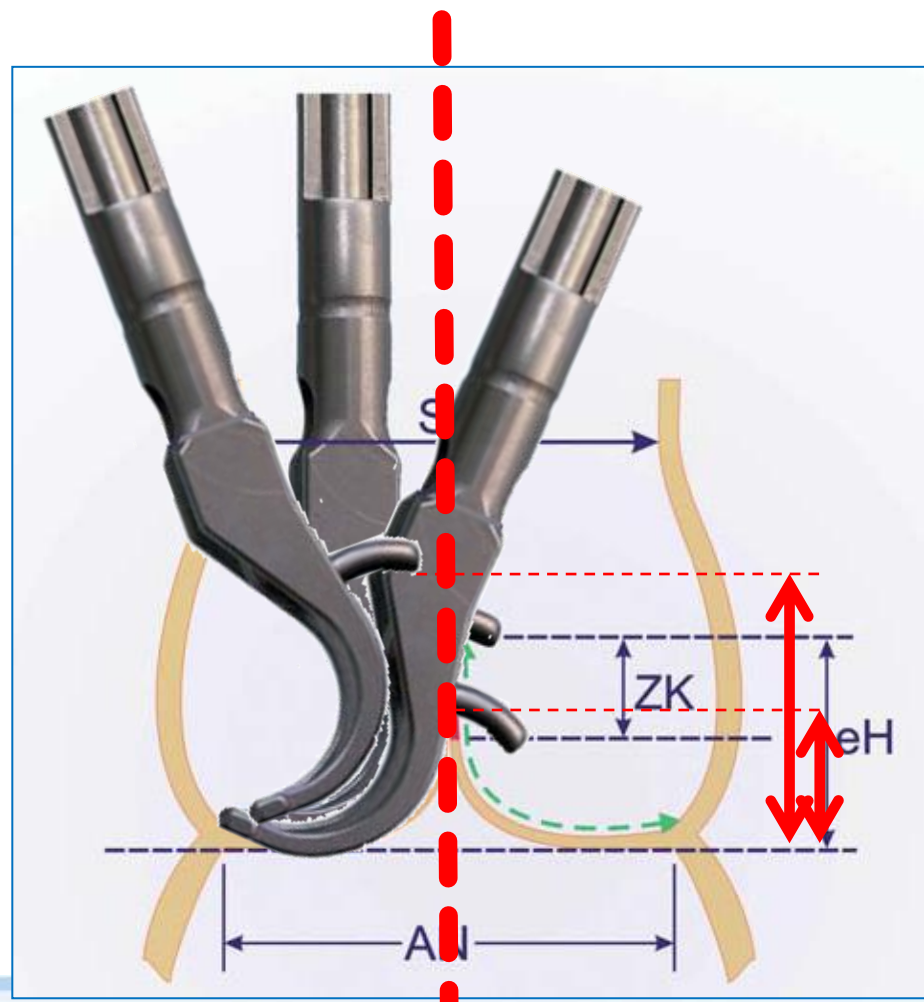
# Cusp Configuration



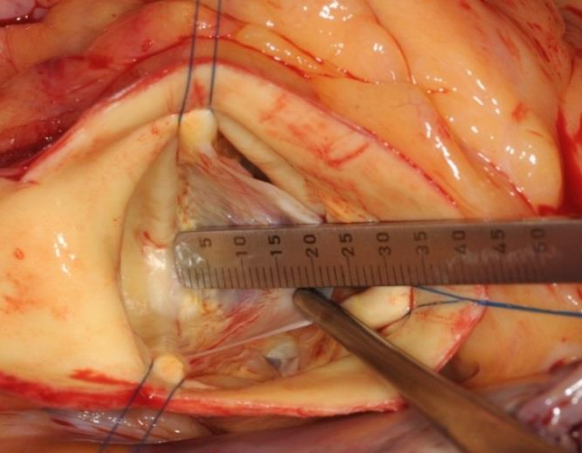
Schäfers HJ et al, JTCVS 2006



# eH Measurement Error

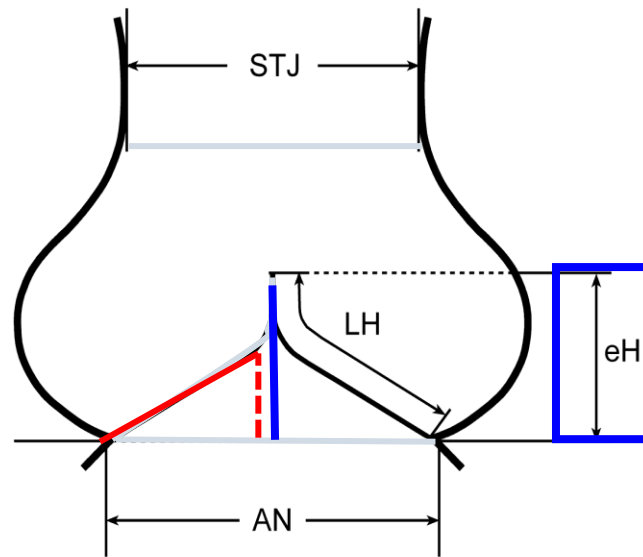
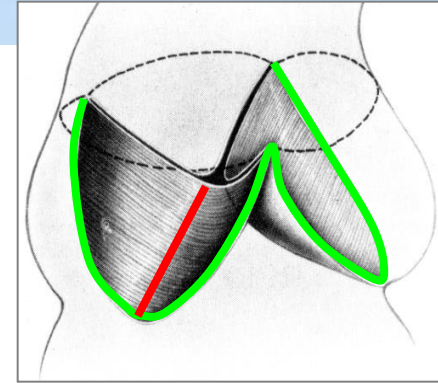






n Folienmaster anpassen)

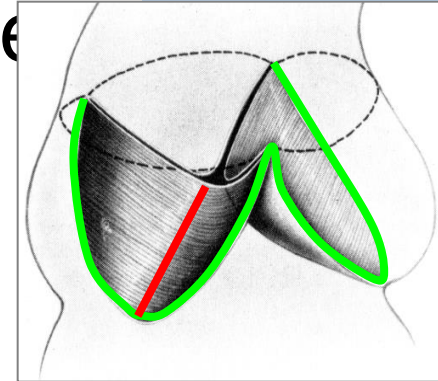
# Configuration of cusps



# Aortic Valve Repair - Assessment

## Solutions

### Configuration/coaptation of cusps



#### Cusp height in aortic valve

Hans-Joachim Schäfers, MD,<sup>a</sup> Wolfram S

**Objectives:** Successful aortic valve repair available on the normal dimensions of I

**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 geom  $\pm 2.0$ ). Significant correlations were for valves, the height of the noncoronary c left coronary cusp varied from 12 to 25 mm (mean,  $20.0 \pm 2.1$ ). The nonco cusp ( $P = .000$ ). No difference was four between the geometric height and clini degree of aortic regurgitation.

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

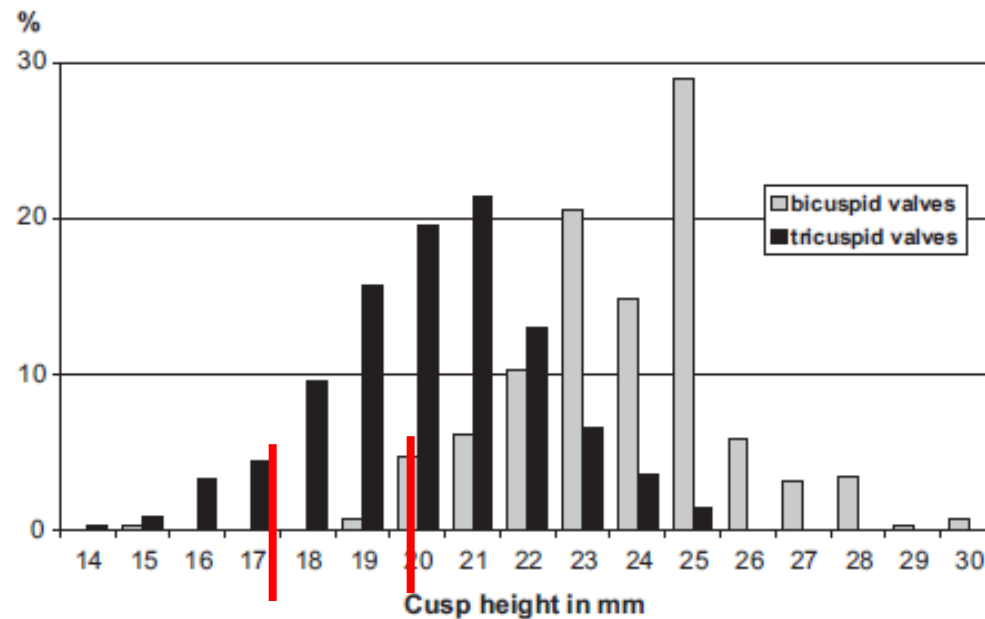
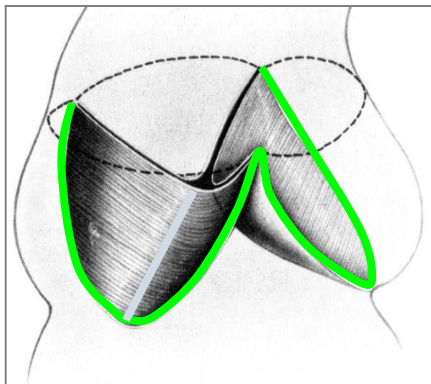


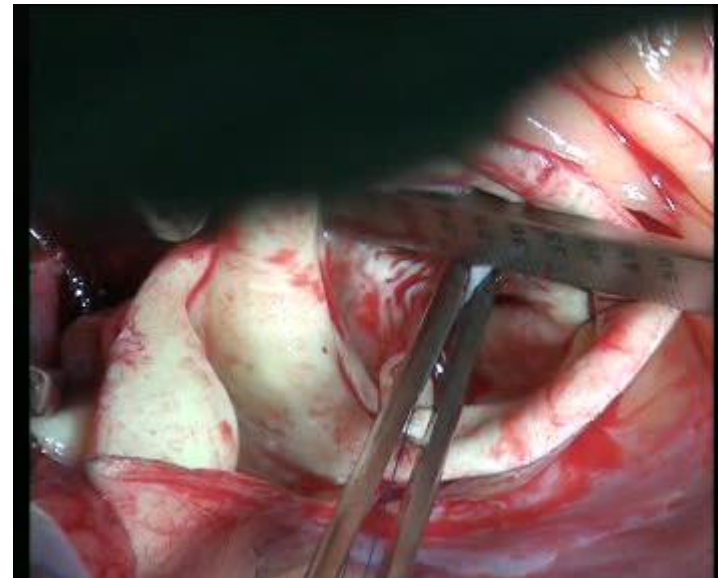
FIGURE 3. Distribution of geometric height in bicuspid (n = 289; nonfused cusps) and tricuspid (n = 332; mean of all 3 cusps) aortic valves.

# Aortic Valve Repair - Assessment

## Configuration/coaptation of cusps



TAV: 17-22 mm  
BAV: 20-25 mm



## 3. Root Correction

If

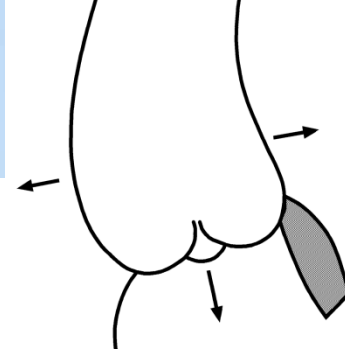
Sinus > 40 -45 mm

Root remodeling  
(Valve reimplantation)

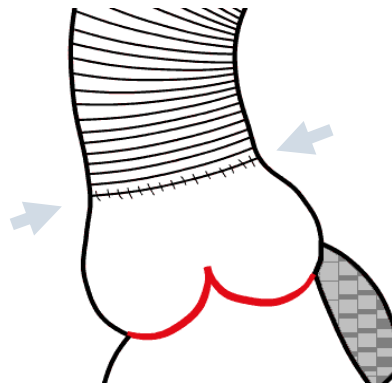
Sinus < 40-45 and STJ > 30-35 mm

STJ remodeling

# Root Repair – Technical Options

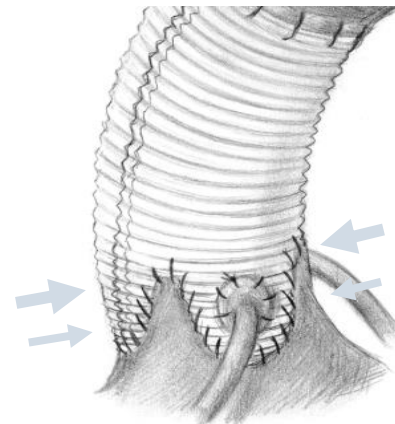


## ST Junction Remodelling



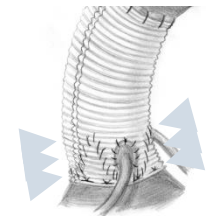
(Frater 1986)  
(Sinus < 40-45 mm)

## Root Remodeling



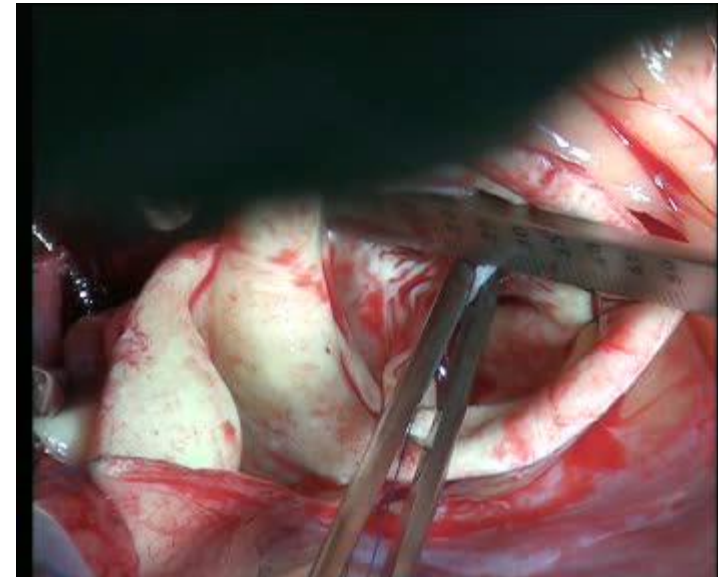
(Yacoub 1993)  
(Sinus > 45 mm),

## Reimplantation of Aortic Valve



(David 1992)  
(AVJ ≥ 30 mm)

# Valve Sparing: Our Routine



1. Measure gH and  
proceed with VPS if  
 $gH \geq 18$  mm

2. (Root remodeling)

Take graft according to patient size

BSA	$< 1.8$ m <sup>2</sup>	24 mm
	1.8 to 2.2 m <sup>2</sup>	26 mm
	$>2.2$ m <sup>2</sup>	28 mm (?)

if  $gH \leq 20$  mm consider graft size 2 mm less

## 4. Cusp Correction

If

prolapse ( $eH \leq 8$  mm)  
structural defect  
anatomical variant

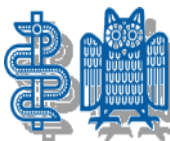
Plication of free margin / triangular resection

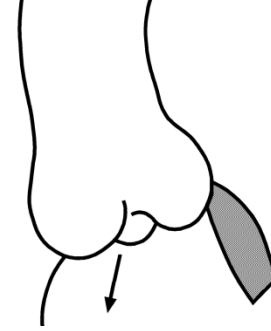
Patch correction

Conversion of anatomy (BAV, TAV constant)

UAV ► BAV

QAV ► TAV

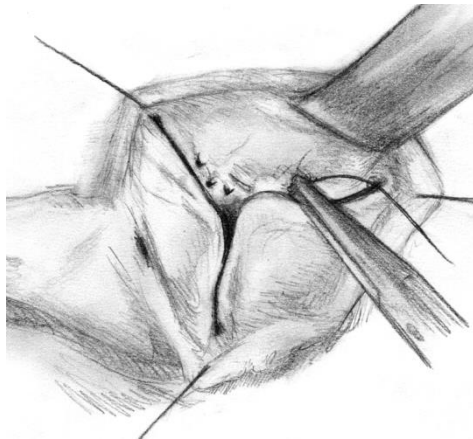




# Reconstructive Techniques

## Cusp Pathology

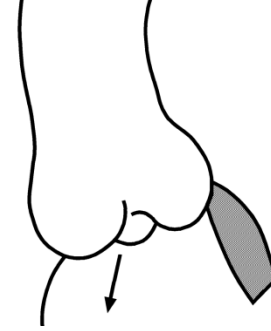
Prolapse



Plication of  
Cusp Margin



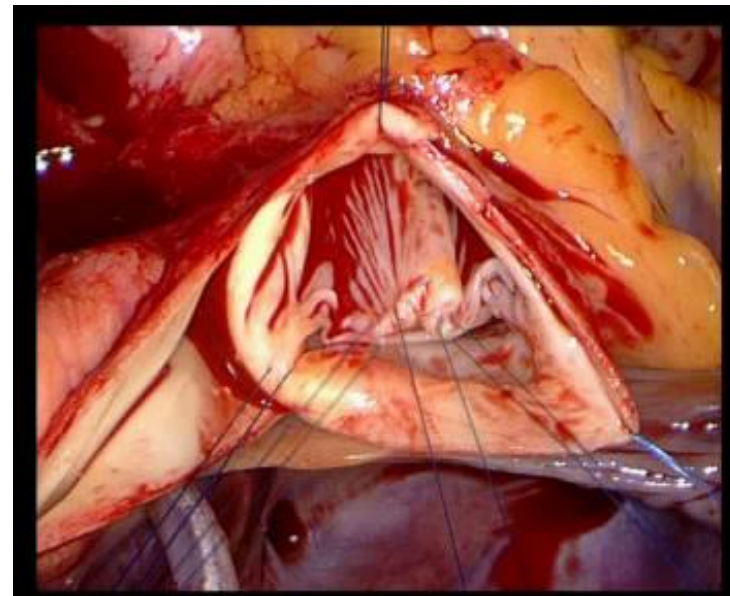
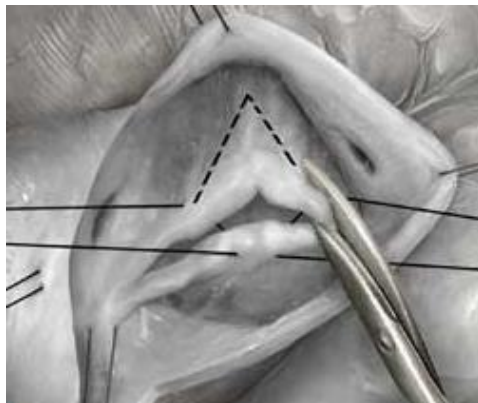




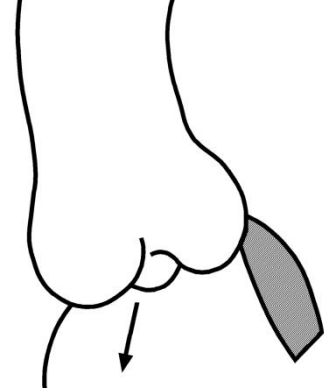
# Reconstructive Techniques

## Cusp Pathology

Fibrosis,  
Calcium,  
Redundancy



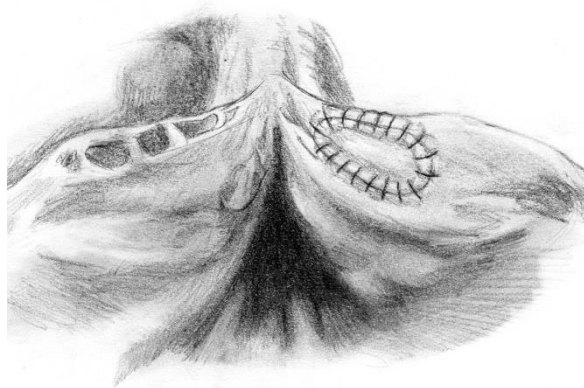
Triangular  
Resection



# Reconstructive Techniques

## Cusp Pathology

Fenestration

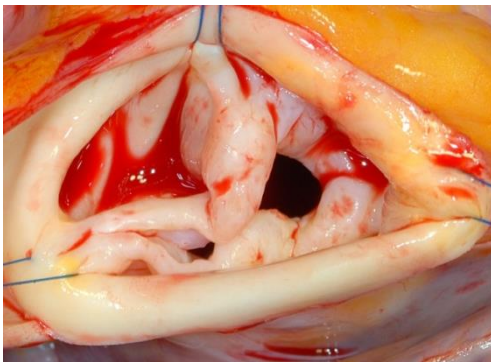


Stabilisation of  
cusp (pericardium)

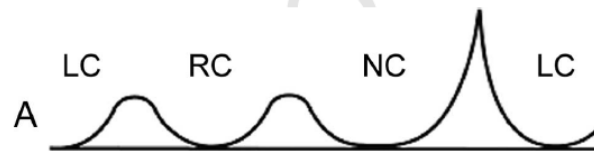


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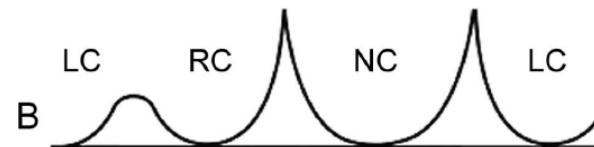
# Bicuspidization of the Unicuspid Aortic Valve



unicuspid

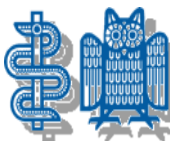


bicuspid



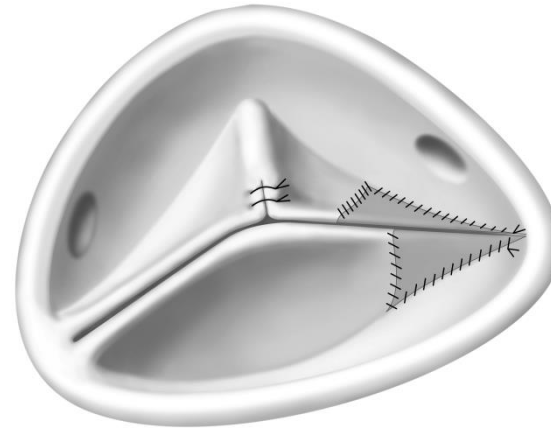
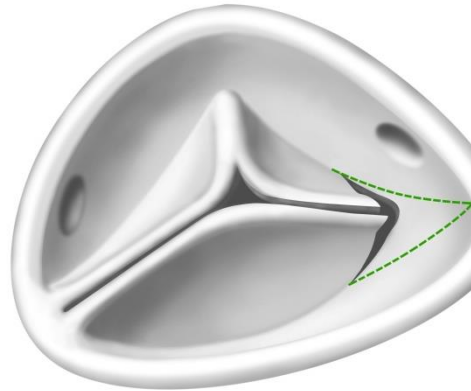
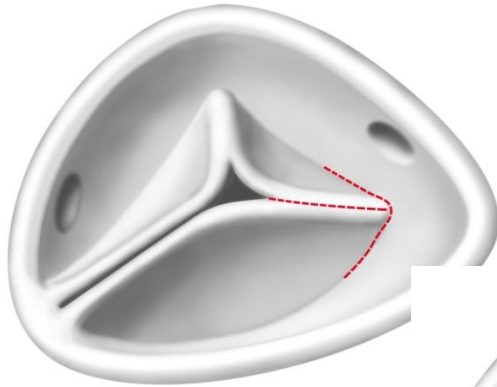
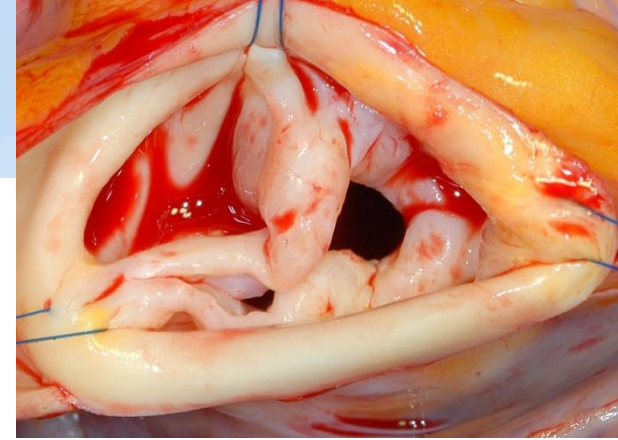
## Aortic Valve Anatomy

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



# Bicuspidization of the Unicuspid Aortic Valve

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

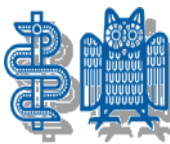
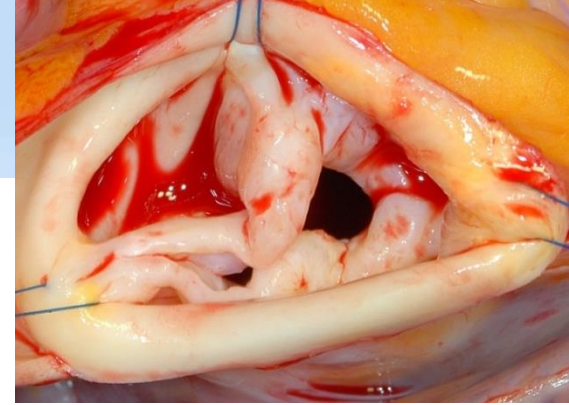
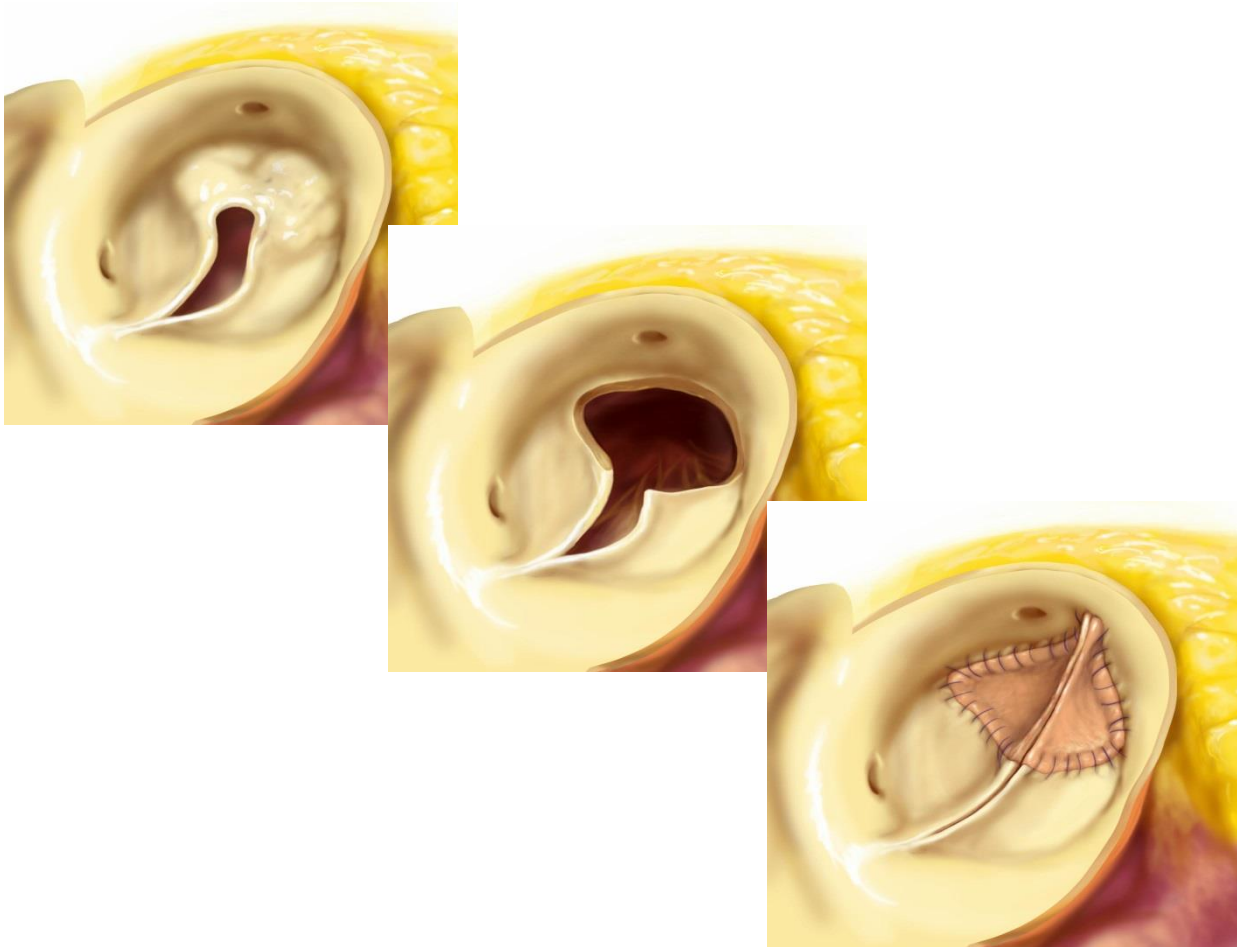


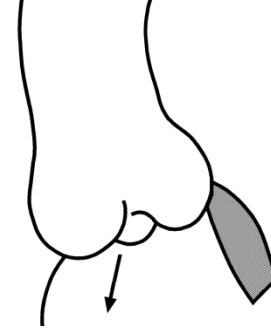
Schäfers HJ, ATS 2008



Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

# Bicuspidization of the Unicuspid Aortic Valve II

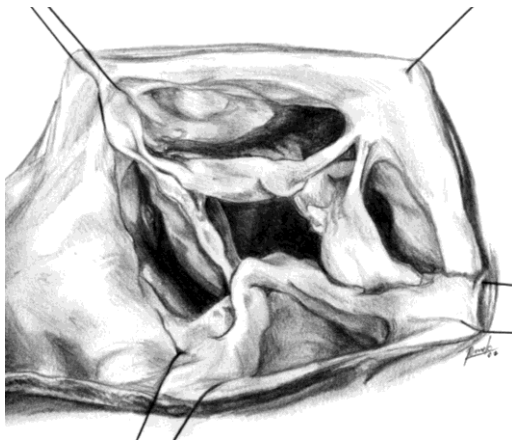




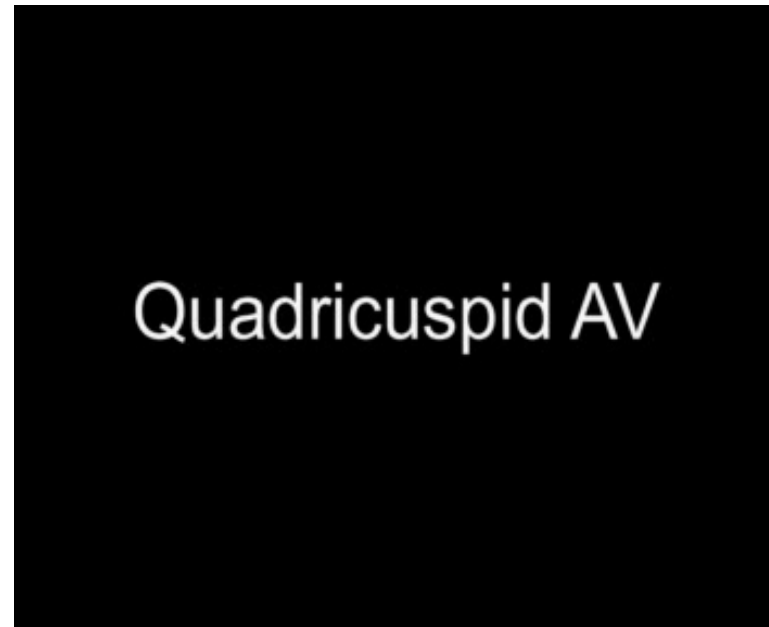
# Reconstructive Techniques

## Cusp Pathology

Anomaly



Conversion of configuration



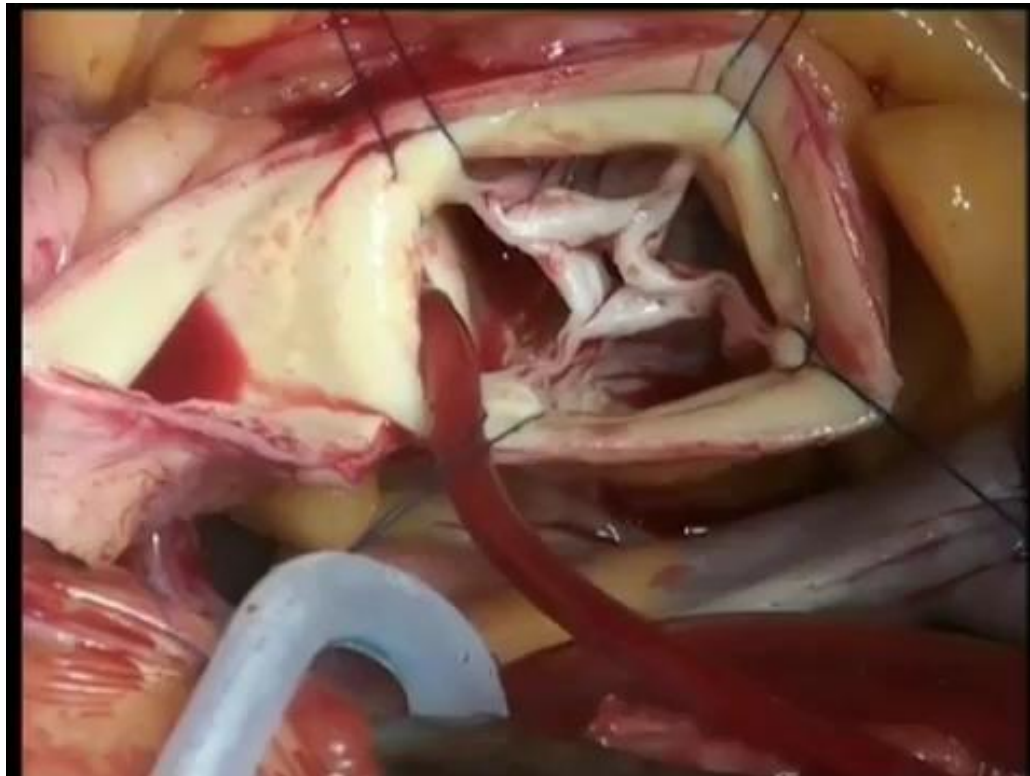
Schmidt et al., Ann Thorac Surg 2007

**Titel des Vortrags** und Verfasser (bitte im Folienmaster anpassen)

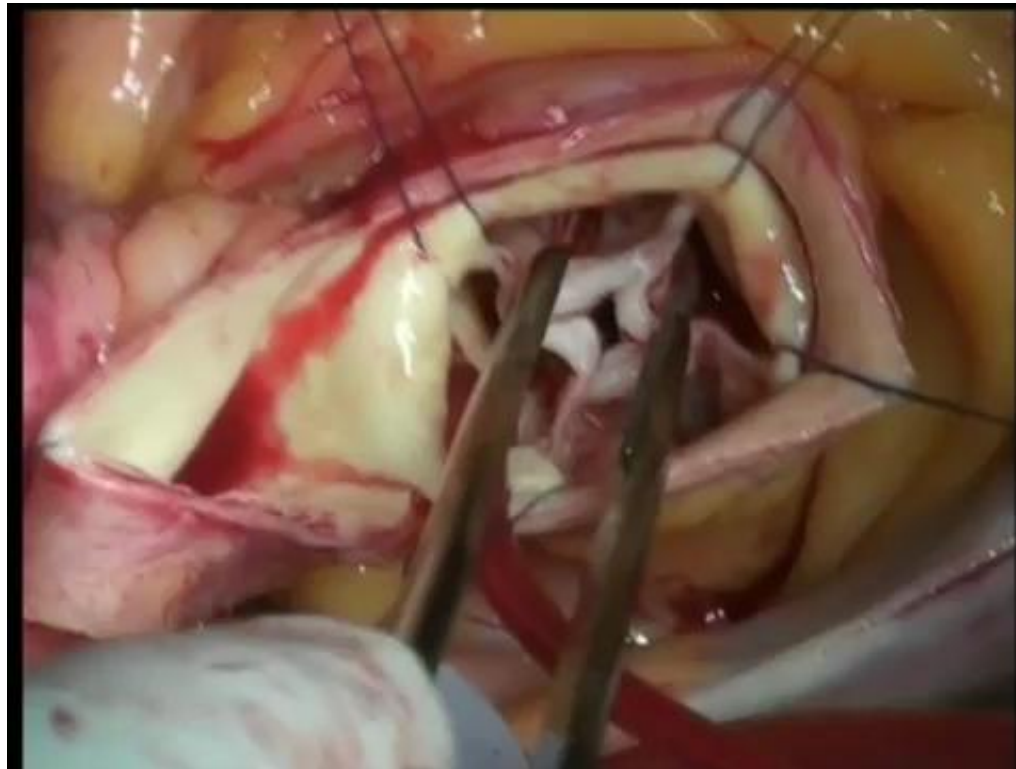




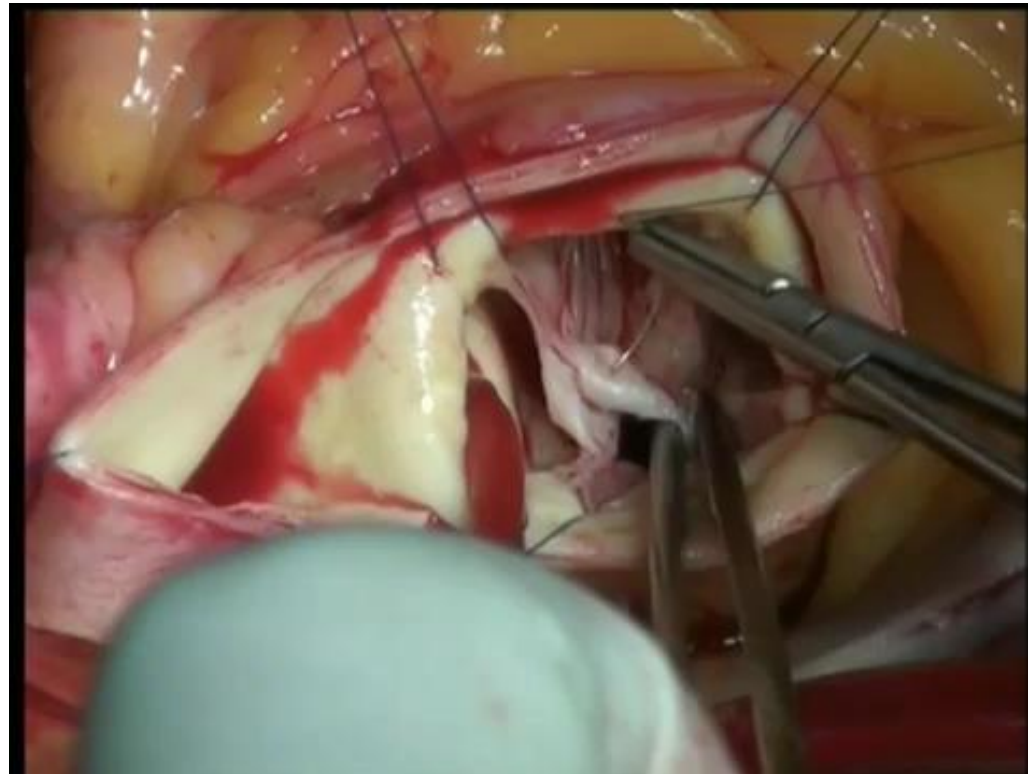
Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)



**Titel des Vortrags** und Verfasser (bitte im Folienmaster anpassen)



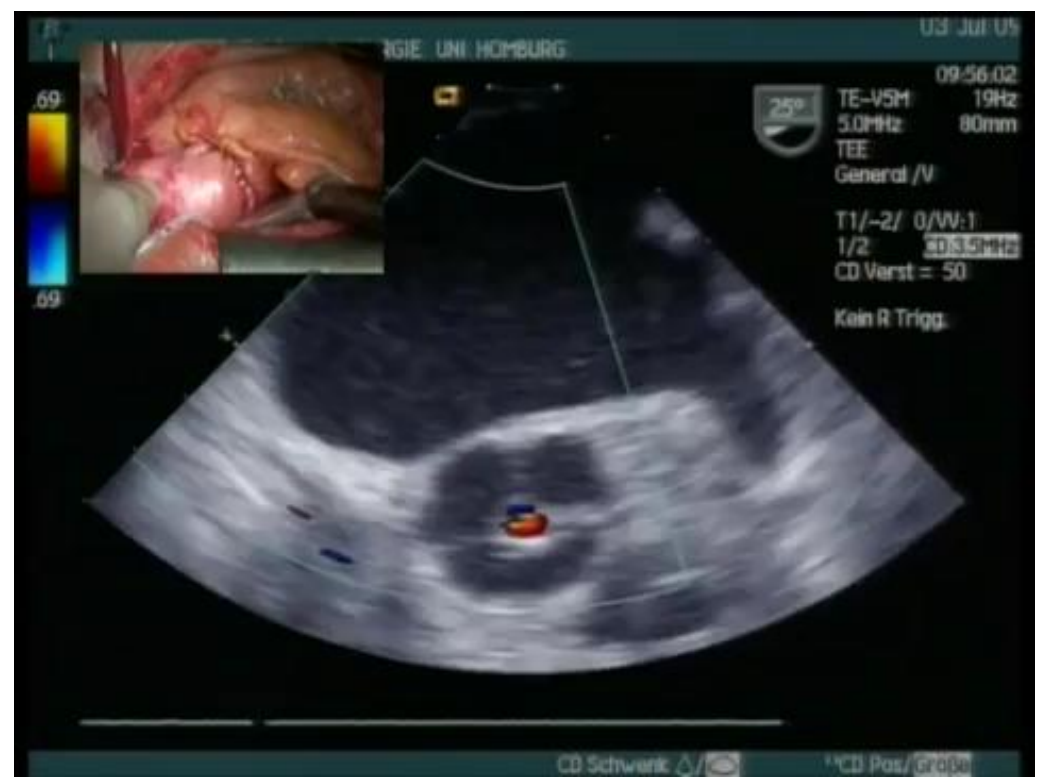
**Titel des Vortrags** und Verfasser (bitte im Folienmaster anpassen)



**Titel des Vortrags** und Verfasser (bitte im Folienmaster anpassen)



**Titel des Vortrags** und Verfasser (bitte im Folienmaster anpassen)



# Annuloplasty

If

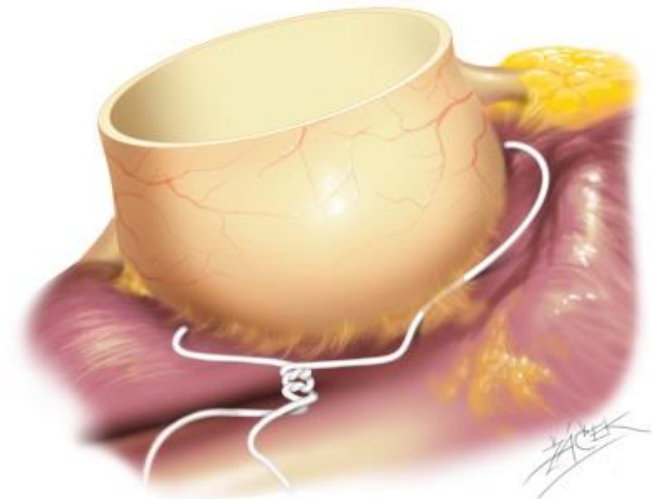
basal diameter  $> 26-27$  mm

Annular reduction

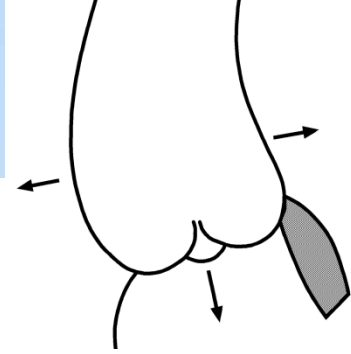
- ▶ 25 mm for BSA  $> 2$  m<sup>2</sup>
- ▶ 23 mm for BSA  $< 2$  m<sup>2</sup>

Reduce by 2 mm for

40 11.05.2017  $gH < 19$  (TAV) / 22 (BAV) mm



# Repair – Technical Options

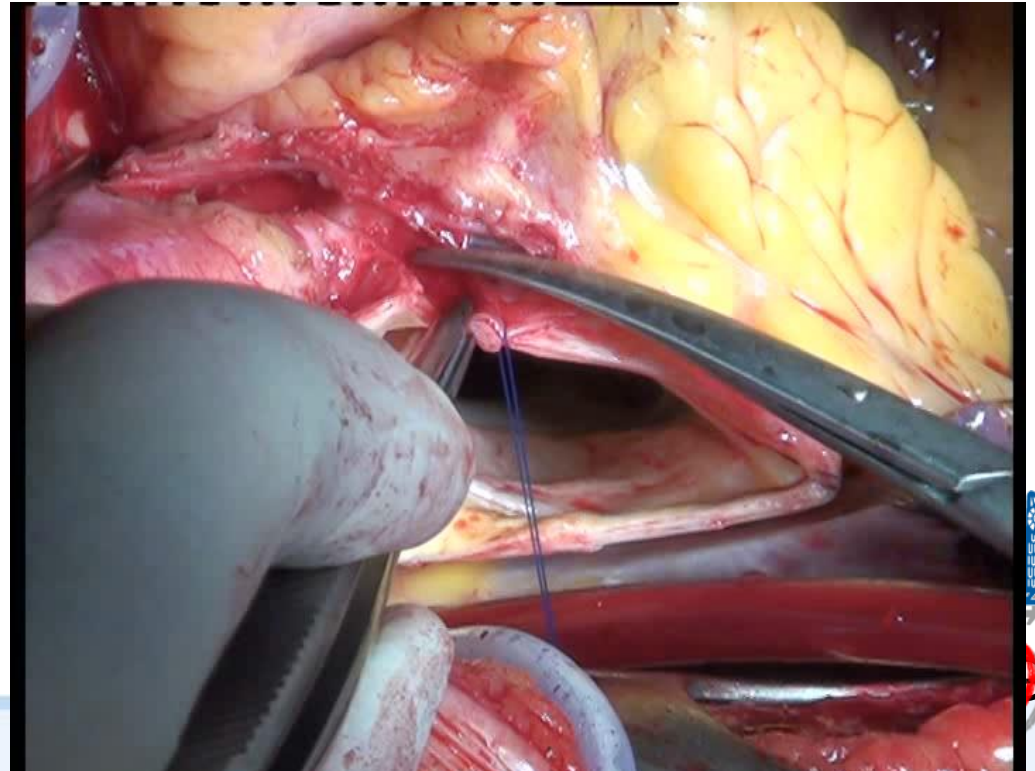
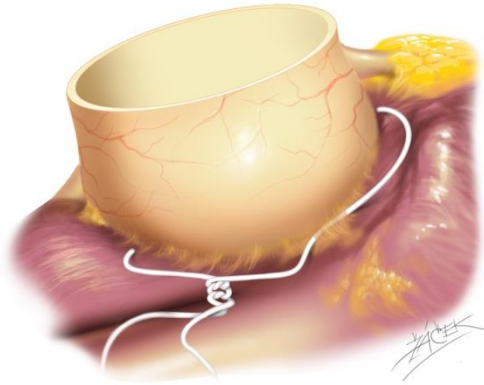


## Aortoventricular Stabilisation (AVJ > 27mm)

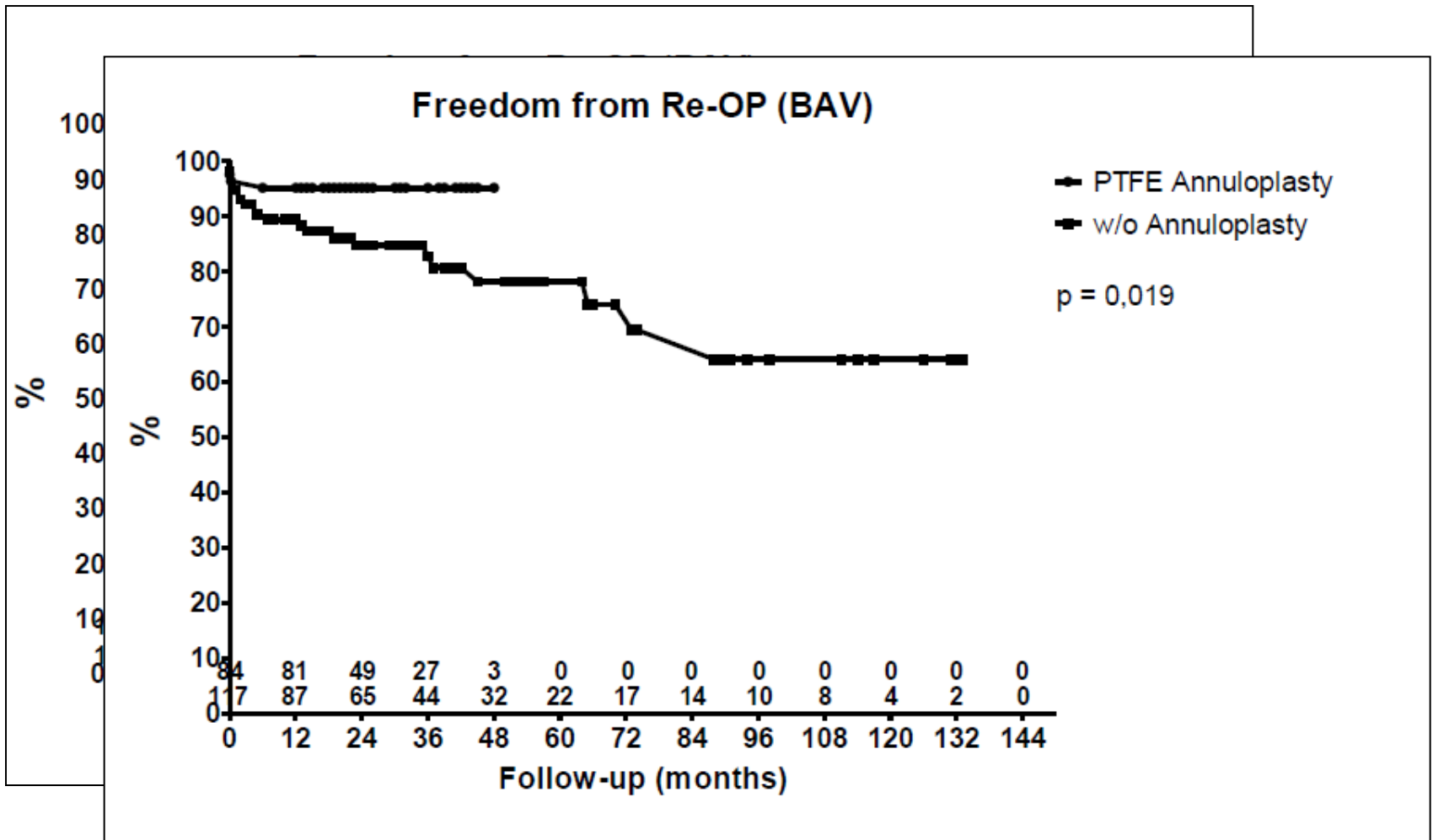
### Subcommissural Plication



(Cabrol 196)



Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)





## In a Nutshell: Standardized Aortic Valve Repair

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

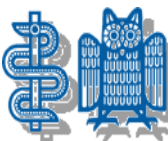


Decision for valve preservation

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

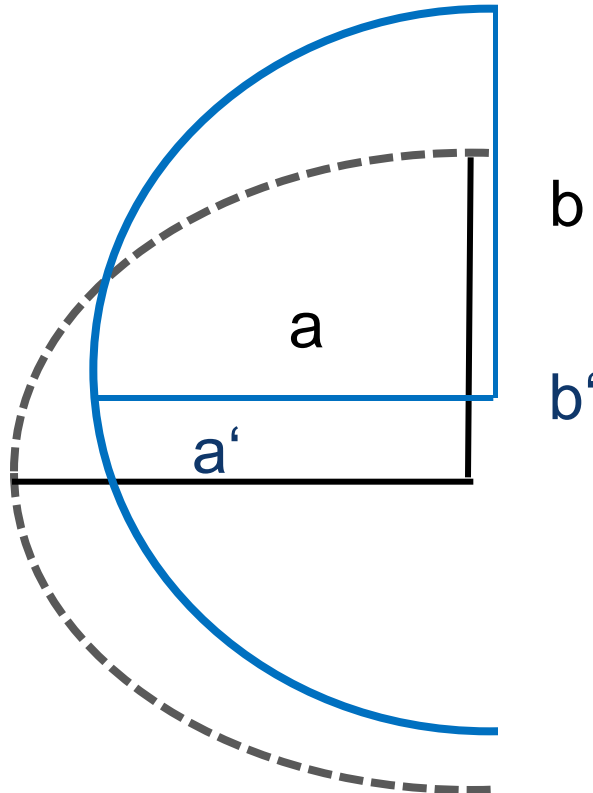


Root replacement



# Reduction of STJ and Cusp Prolapse

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)



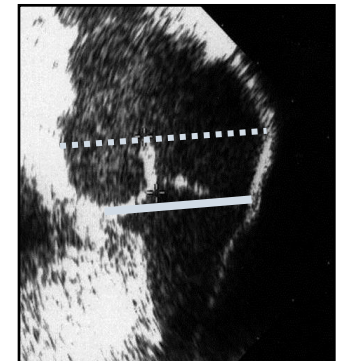
$$C_E = \pi \times [3/2 \times (a+b) - \sqrt{a \times b}]$$

$$b \approx r_{\text{aorta}}$$

$$a \approx r_{\text{cusp}}$$



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



## In a Nutshell: Standardized Aortic Valve Repair

### 3. No root enlargement

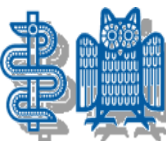


Isolated cusp repair

### 4. Annular diameter $> 26-27$ mm (or $gH < 20$ in TAV, $< 22$ in BAV)



Annuloplasty



# Standardized Aortic Valve Repair

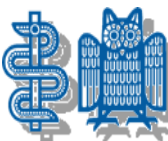
5. If root + cusp necessary,



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

Annular stabilization as needed (AI, durability)

6. Correction of cusp prolapse (eH)

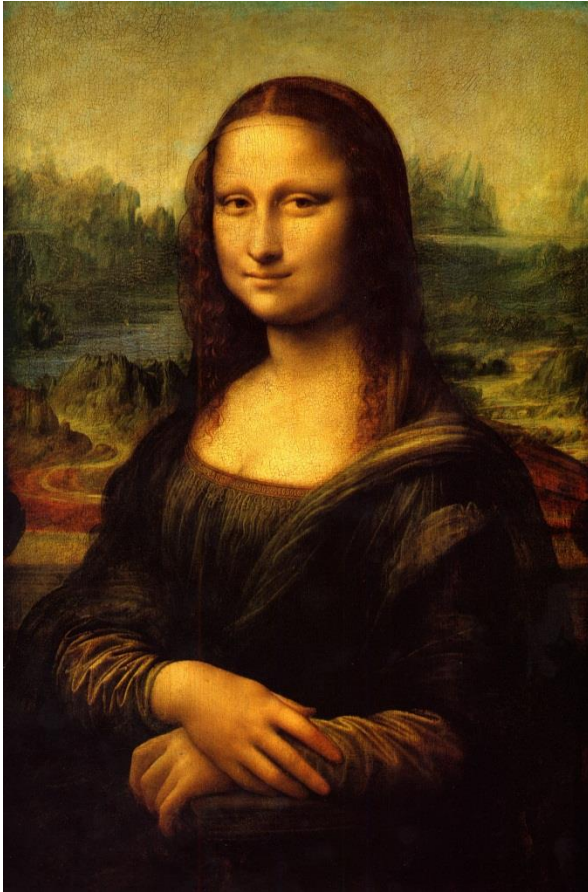


# Conclusions

- Systematic analysis + correction of pathologic components
- Many strategies defined
- Geometric height aids in selecting good substrate
- Normalize cusp configuration (effective height)!
- Specific valve configurations require tailored approach

Titel des Vortrags und Verfasser (bitte im Folienmaster anpassen)

# Aortic Valve Reconstruction



Thank you for your attention

