

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

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## ABSTRACT

**Objective:** The lack of annular stabilization is the drawback of aortic root remodeling, and recently the addition of annuloplasty has been proposed. Limited data, however, exist on late annular size after remodeling. We studied annular size over time.

**Methods:** In 241 patients ( $53 \pm 16$  years) annular size was determined preoperatively (T0), before discharge (T1), and at least 2 years after remodeling (T2,  $54 \pm 27$  months) with ( $n = 52$ ) or without external suture annuloplasty. Seventeen patients had Marfan syndrome (7%), 100 a bicuspid valve (41%), and 22 acute dissection (9%). Mean graft size was  $25.2 \pm 1.3$  mm, and annuloplasty size  $24.3 \pm 1.4$  mm.

**Results:** Annular size was significantly reduced after repair and remained stable over time (T0:  $27.4 \pm 3.0$  mm, T1:  $24.2 \pm 2.5$  mm, T2:  $24.2 \pm 2.6$  mm). After propensity-score matching ( $n = 33$  each), baseline annular size was similar (with annuloplasty vs without:  $28.7 \pm 4.1$  mm vs  $27.8 \pm 2.8$  mm). Annular reduction was less effective without annuloplasty ( $23.9 \pm 2.0$  mm vs  $25.6 \pm 2.2$  mm,  $P < .01$ ); size was identical at follow-up ( $23.8 \pm 2.2$  mm vs  $25.1 \pm 2.5$  mm,  $P = .03$ ). After matching, freedom from annular size increase  $>10\%$  at 4 years was  $93 \pm 5\%$  without annuloplasty and  $91 \pm 9\%$  with annuloplasty ( $P = .92$ ). A linear mixed-effects model identified no significant effect of annuloplasty on annulus diameter change at T2 ( $P = .48$ ). Era after 2004, Marfan syndrome, and smaller annulus diameter at discharge were the independent predictors for late annular expansion.

**Conclusions:** Aortic annulus rarely dilates over time after remodeling. In the case of annular dilatation, annuloplasty normalizes annular size and may prevent further dilatation by enhancing cusp coaptation. Even without annuloplasty, the aortic annulus becomes smaller compared with preoperative dimensions when aortic valve remains competent. (J Thorac Cardiovasc Surg 2017; ■:1-10)

Two types of valve-preserving root replacement have been performed to treat aortic root dilatation with or without aortic valve regurgitation (AR) in the last 2 decades.<sup>1,2</sup>

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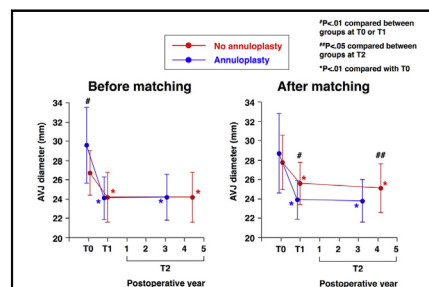
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Aortoventricular junction diameter in patients with or without annuloplasty.

## Central Message

The aortic annulus rarely dilates over time after remodeling with annuloplasty in cases with annular dilatation. Even without annuloplasty, it becomes smaller, which may be due to annular reverse remodeling.

## Perspective

The aortic annulus rarely dilates over time after remodeling, at least in cases without marked annular dilatation at the time of surgery. If annular dilatation is present, external suture annuloplasty normalizes annular size and prevents further dilatation. Even without annuloplasty, aortic annulus becomes smaller over time when aortic valve remains competent, which may be due to annular reverse remodeling.

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Aortic root remodeling is one of these alternatives and has been established as a simple, physiological, and effective procedure. We have reported favorable long-term outcomes with sufficient caseload over 15 years.<sup>3</sup> The major advantage of remodeling technique is the preservation of interleaflet triangles, which is believed to play a key role in optimal root hemodynamic physiology.<sup>4</sup>



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**Abbreviation and Acronyms**

AR = aortic valve regurgitation  
 AVJ = aortoventricular junction  
 BAV = bicuspid aortic valve  
 TAV = tricuspid aortic valve

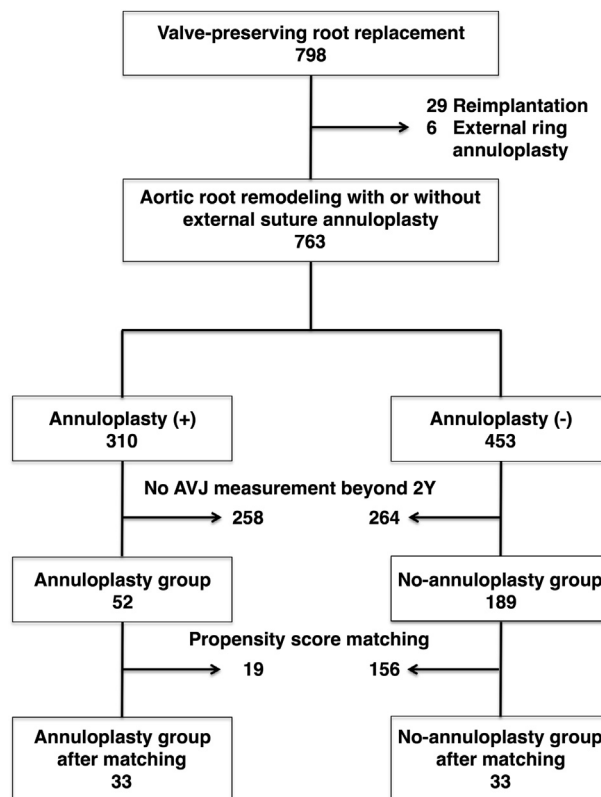
However, most surgeons are still reluctant to apply remodeling because one of the drawbacks of this technique is the assumed lack of annular stabilization and the resultant risk of late aortic regurgitation, especially in cases with connective tissue disease<sup>5</sup> or large annulus.<sup>3,6</sup>

Therefore, different modifications of aortic annuloplasty have been proposed: external suture annuloplasty,<sup>7</sup> external ring annuloplasty,<sup>8</sup> and internal ring annuloplasty.<sup>9</sup> Each has both advantages and disadvantages, and the superiority of one alternative over others remains unclear because of the lack of long-term data. We have consistently applied external suture annuloplasty in cases with pre-existing annular dilatation regardless of root replacement because it is simple and effective.<sup>3,7</sup> With satisfactory mid-term results and low invasiveness, we have now applied annuloplasty for all patients undergoing aortic valve/root repair routinely to enhance cusp coaptation and to prevent late annular dilatation. It is, however, unclear whether the annuloplasty contributes to valve stability, and, if so, in which patients. In a retrospective analysis, we studied annular size over time after remodeling with or without annuloplasty to confirm our hypothesis that annuloplasty can normalize the large annulus and stabilize over time.

**MATERIAL AND METHODS****Patients**

Between October 1995 and December 2013, 798 patients underwent valve-preserving root replacement by a single surgeon (H.J.S.). Of these, 29 patients who underwent aortic valve reimplantation and 6 patients treated with external ring annuloplasty were excluded. Among the remaining 763 patients, external suture annuloplasty was performed in 310 patients (41%) since January 2009. Echocardiography was scheduled at 3 and 12 months postoperatively, then annually or every 2 years. The majority of patients were followed by referral cardiologists, who sent their echo studies for follow-up analysis. In-house echocardiography with measurement of aortoventricular junction (AVJ) diameter at least more than 2 years after the operation was performed in 241 patients, who were further analyzed in this study (Figure 1). Follow-up was complete in these individuals. Annual number of cases using each technique including additional technical modifications is illustrated in the Figure E1. The institutional ethical committee approved the anonymous use of patient data.

Their mean age was  $53 \pm 16$  years, and the majority were male ( $n = 184$ , 76%). Eight patients (3%) had undergone previous cardiac/aortic surgery through a median sternotomy. Aortic valve repair had been performed in 4, mitral valve repair in 1, coronary artery bypass grafting in 1, replacement of the ascending aorta due to acute aortic dissection in 1, and Ross operation in 1. Seventeen patients (7%) suffered from Marfan syndrome, and 100 patients (41%) had bicuspid aortic valve (BAV) anatomy. Twenty-two patients (9%) were operated in the emergent setting due to type A acute aortic dissection. Preoperative mean AR grade was  $2.5 \pm 0.8$  (Table 1).



**FIGURE 1.** A Consolidated Standards of Reporting Trials–type diagram of all patients who underwent aortic root remodeling with or without external suture annuloplasty. AVJ, Aortoventricular junction.

**Indication and Operative Technique**

Our routine technique of remodeling and anesthesia has been described in detail previously.<sup>6</sup> Preoperatively, all patients underwent transesophageal echocardiography (ATL HDI-3000 [Philips Ultrasound, Bothell, Wash] or Sequoia 256 [Acuson Corp, Mountain View, Calif]). The diameter of sinuses of Valsalva, AVJ, and sinotubular junction as well as AR grade were measured as shown in Table 1. When the aortic root was dilated ( $\geq 43$ –45 mm depending on patient size), valve-sparing root replacement was performed if the cusps were pliable and not retracted. For BAV anatomy, this threshold was slightly lower than tricuspid aortic valve (TAV), although a decision-making was really subjective. The degree of AR, the presence of cusp prolapse or fenestrations, and size of aortic root were not considered as exclusion criteria for valve preservation. Initially, we performed remodeling in cases with AVJ  $\leq 29$  mm and reimplantation with larger AVJ. Since January 2008, we have only applied root remodeling.

For TAV, 3 sinuses were excised, and a Dacron graft was chosen with similar diameter of the native AVJ, also taking the size of the patient into consideration. We used a 26-mm graft most frequently ( $n = 146$ ) followed by a 24-mm graft ( $n = 79$ ) (Table E1). Three tongues were created equally and the graft sutured into the aortic root close to the cusp insertion lines. Care was taken to create maximum height of the commissures. In cases with BAV, 2 symmetrical tongues were created and 2 commissures were repositioned in the  $180^\circ$  angle.

In 52 patients since January 2009, an external circular suture annuloplasty using a CV-0 expanded polytetrafluoroethylene suture (W. L. Gore & Associates, Inc, Flagstaff, Ariz) was added<sup>7</sup> (the annuloplasty group; the other 189 patients were the no-annuloplasty group). The suture was circularly passed around the outside of the root at

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