

Remodeling root repair with an external aortic ring annuloplasty

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ABSTRACT

Objective: Although the remodeling technique provides the most dynamic valve-sparing root replacement, a dilated annulus (>25 mm) is a risk factor for failure. Aortic annuloplasty aims to reduce the annulus diameter, thus increasing coaptation height to protect the repair. The results of 177 patients with remodeling and external aortic ring annuloplasty were studied.

Methods: Data were collected from the Aortic Valve repair InternATIonal Registry. Preoperative aortic insufficiency grade 3 or greater was present in 79 patients (44.7%). The valve was bicuspid in 59 patients (33.3%). External annuloplasty was performed through a homemade Dacron ring (56) or a dedicated expansible aortic ring (121).

Results: Thirty-day mortality was 2.9% (5). Mean follow-up was 41.1 ± 36.4 months. For the whole series, freedom from valve-related reoperation, aortic insufficiency grade 3 or greater, aortic insufficiency grade 2 or greater, and major adverse valve-related events were 89.5%, 90.5%, 77.4%, and 86.6% at 7 years, respectively, with similar results for tricuspid and bicuspid valves. Since 2007, systematic use of calibrated expansible ring annuloplasty, followed 1 year later by systematic cusp effective height assessment, significantly increased 7-year freedom from valve-related reoperation, aortic insufficiency grade 3 or greater, and major adverse valve-related events up to 99.1% ± 0.9% ($P = .017$), 100% ($P = .026$), and 96.3% ± 1.8% ($P = .035$), respectively, whereas freedom from aortic insufficiency grade 2 or greater remained unaffected (78.1% ± 7.6%). Calibrated annuloplasty and effective height assessment were identified as protective factors from reoperation: hazard ratio, 0.13; 95% confidence interval, 0.02-1.06; $P = .057$ and hazard ratio, 0.11; 95% confidence interval, 0.01-0.95; $P = .044$, respectively.

Conclusions: The standardization of remodeling root repair with calibrated expansible aortic ring annuloplasty and cusp effective height assessment improves valve repair outcomes. (*J Thorac Cardiovasc Surg* 2017; ■:1-10)

Recent guidelines on the management of aortic diseases mentioned “aortic annuloplasty” as part of a class I indication: “Aortic valve repair, using the reimplantation technique or the remodeling technique with aortic annuloplasty, is recommended in young patients with aortic

root dilation and tricuspid aortic valves.”¹ Although the remodeling technique provides physiologic cusp movement within the 3 reconstructed neo-sinuses, thus preserving root expansibility through the interleaflet triangles, an untreated dilated aortic annulus (>25-28 mm) has been identified as a

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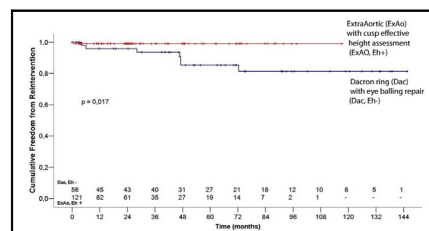
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Freedom from reoperation (ExAo + cusp effective height, Dacron ring + eyeballing).

Central Message

Remodeling with calibrated expansible aortic ring annuloplasty and cusp effective height assessment improves valve repair outcomes.

Perspective

Standardization of the valve-sparing procedure through remodeling root repair with a calibrated expansible aortic ring annuloplasty and cusp effective height assessment should improve the reproducibility and rate of valve repair, even in severe AI. Because repair of bicuspid valves provides stable results similar to those of tricuspid valves, it may be offered for aneurysm with pliable bicuspid valves.

Abbreviations and Acronyms

AI	= aortic insufficiency
AVIATOR	= Aortic Valve repair InternATIOnal Registry
CI	= confidence interval
ExAo	= expansible aortic ring diameter
HR	= hazard ratio
MAVRE	= major adverse valve-related events

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risk factor for failure.²⁻¹⁰ Furthermore, most failures with valve-sparing techniques are due to residual cusp prolapse as a primary unrecognized lesion or secondary to an induced prolapse after root reconstruction.^{11,12} As a result, the rate of valve repair remains low and is practiced on highly selected patients, except in a few expert centers. Although more than 80% of aortic root aneurysm surgeries are undertaken for dystrophic aortic insufficiency (AI) (with tricuspid, bicuspid, or unicuspid valve), a recent analysis of the Society of Thoracic Surgeons database revealed that only 14% of these patients receive a valve-sparing procedure.¹³⁻¹⁵ This fact brings into question the reproducibility and lack of technical standardization associated with these current procedures.

To address these issues, a standardized aortic valve repair approach addressing both the aorta and the valve was developed, associating a physiologic reconstruction of the aortic root according to the remodeling technique, with cusp effective height resuspension and a subvalvular external aortic ring annuloplasty, which we analyzed in this study.^{8,16-20}

MATERIALS AND METHODS**Patient Population**

This analysis focuses on all consecutive patients undergoing operation with the remodeling technique associated with an external aortic ring annuloplasty by Dr Lansac (or under his direct proctoring) in the successive centers where he worked, from May 2003 to November 2015, making this study the longest follow-up of the external aortic ring annuloplasty. Patient characteristics and 30-day outcomes are detailed in Table 1. Two patients underwent operation for acute aortic dissection. Preoperative AI grade 3 or greater was present in 44.7% of patients. Interventions were performed in 4 institutions in France: University Hospital La Pitie Salpetriere, University Hospital Bichat-Claude Bernard, Foch Hospital, and, since 2010, Institut Mutualiste Montsouris. Data were prospectively collected in the

multicentric international Aortic Valve repair InternATIOnal Registry (AVIATOR), including 35 patients from the Conservative Aortic Valve surgery for aortic Insufficiency and Aneurysm of the Aortic Root trial²¹ (ClinicalTrials.gov identifier: NCT00478803). This study was approved by the institutional review boards for the multicentric AVIATOR (Comité Consultatif sur le Traitement de l'Information en matière de Recherche dans le Domaine de la Santé n° 13,738 Bis) and multicentric Conservative Aortic Valve surgery for aortic Insufficiency and Aneurysm of the Aortic Root trial (Comité de Protection des Personnes Ile de France VI A00362-49). The need for individual patient consent was waived.

Surgical Technique

All patients underwent the standardized approach to aortic valve-sparing root replacement to treat dilation of the aortic annulus (≥ 25 mm) as measured intraoperatively with the Hegar dilator¹⁴ (Figure 1). Cusp geometric height was assessed to detect valve retraction, defined as less than 16 mm for tricuspid cusps and less than 20 mm for the nonfused cusp in bicuspid valves; these values are considered the cutoff for valve replacement.²² After resecting the sinuses of Valsalva, an external dissection of the aortic root is performed down to the aortic annulus. Native aortic annulus diameter is measured with Hegar dilators because it is the sole criterion for selecting the sizes of the aortic ring and the graft used to remodel the aortic root (Gelweave Valsalva; Vascutek Ltd, Glasgow, UK) (Table 2). The expansible aortic ring diameter (ExAo) is undersized by 1 size relative to the measured native annulus diameter: annulus 25 to 27 mm (ExAo 25 mm/Valsalva 26 mm); annulus 28 to 30 mm (ExAo 27/Valsalva 28); annulus 31 to 35 mm (ExAo 29/Valsalva 30); annulus greater than 36 mm (ExAo 31/Valsalva 32). Six "U" stitches are placed circumferentially from inside-out in the subvalvular plane, below the nadir of each cusp and at the base of each interleaflet triangle, except between the right and noncoronary sinuses, where the sixth stitch is placed externally on the atrium wall at the lowest level of dissection to avoid potential lesion to the bundle of His or membranous septum. The first step of valve repair, done before root reconstruction, consists of aligning the cusp free edges and correcting any excess free margin length through central plicating stitches or cusp resection. Remodeling of the aortic root is standardized by scalloping the Valsalva graft into 3 symmetrical neo-sinuses (placing the commissures at 120° in tricuspid valves) (Video 1) or 2 symmetrical neo-sinuses (placing the commissures at 180° in bicuspid valves) (Video 2). The heights of the scallops are cut equally up to the transition point between circumferential and axial folds of the graft, thus ensuring that the commissures are placed at the same level. The second step of cusp repair is performed after root reconstruction and consists of assessing cusp effective height with a dedicated cusp caliper (Fehling Instruments, Karlstein, Germany) to evaluate residual or induced cusp prolapse according to the principle of Schäfers and colleagues.²³ Plicating stitches are added on the free edge of the culprit leaflet until an effective height of 9 mm is achieved.

The 6 anchoring "U" stitches are passed around the expansible aortic ring, which is seated externally around the remodeled aortic root and tied in the subvalvular position. In earlier experience, the ring was homemade from a slice of a Dacron tube graft and used in 56 patients (31.6%). Since 2007, a calibrated expansible aortic ring (Extra-Aortic; CORONEO, Inc, Montreal, QC, Canada) has been used (121 patients, 68.4%).¹⁹

Intraoperative transesophageal echocardiography was performed in all cases. Any residual AI greater than grade 1 mandated reexploration of the aortic valve. Postoperative anticoagulation consisted of aspirin (75 mg/d) administered for 2 months unless persistent atrial fibrillation presented, in which case oral anticoagulation was used. For all patients, clinical and echocardiographic data were collected and manually entered into the AVIATOR preoperatively and perioperatively, at discharge, and yearly thereafter through patient visits to cardiologists or surgeons or via direct contact with the patient.

Primary end points were all causes and valve-related mortality and reoperation at 30 days and follow-up periods. Secondary end points were

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