

## Recurrence of mitral regurgitation after partial versus complete mitral valve ring annuloplasty for functional mitral regurgitation

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**Objectives:** Both partial and complete annuloplasty rings are used for mitral valve repair for patients with functional mitral regurgitation (FMR). We sought to determine if recurrence of mitral regurgitation (MR) is affected by the type of ring used.

**Methods:** Five hundred forty-eight patients diagnosed with FMR underwent mitral valve repair with ring annuloplasty between 1998 and 2008 in our institution. Medical records were reviewed retrospectively for clinical and echocardiographic data to determine the presence of recurrent MR (defined as moderate or severe).

**Results:** Among 479 patients for whom postoperative echocardiographic data were available, recurrent MR occurred less frequently in the complete versus partial ring group (20 of 209 [10%] vs 56 of 270 [21%] patients;  $P = .001$ ), despite lower preoperative ejection fractions in the complete ring group (median, 35%; interquartile range, 25%-45% vs median, 40%; interquartile range, 30%-55%;  $P < .001$ ). Kaplan-Meier analysis demonstrated greater freedom from recurrent MR in the complete ring group (108 vs 103 months;  $P = .001$ ). Risk-matched propensity analysis of 102 patients per group (area under the curve, 0.824; 95% confidence interval, 0.788-0.861;  $P < .001$ ) also demonstrated that complete ring recipients had greater freedom from recurrent MR than partial ring recipients by univariate analysis (7 [7%] vs 17 [17%] patients;  $P = .049$ ), and a trend toward greater freedom by Kaplan-Meier analysis (110 vs 104 months;  $P = .068$ ).

**Conclusions:** The use of complete mitral annuloplasty rings provides improved freedom from recurrent MR in patients with FMR. (*J Thorac Cardiovasc Surg* 2013;146:616-22)

Functional mitral regurgitation (FMR) is a type of mitral regurgitation (MR) that occurs despite structurally normal mitral valve leaflets, usually in patients with advanced ischemic or idiopathic dilated cardiomyopathy.<sup>1,2</sup> FMR carries a poor prognosis with medical treatment alone, resulting in 1-year survival rates of 52% to 87% and 5-year survival rates of 22% to 54%.<sup>3-6</sup>

The pathophysiology of FMR is complex. As dilated cardiomyopathy worsens, ongoing left ventricular remodeling and dilation are associated with subtle structural changes to the mitral valve apparatus, including mitral annular dilation, lateral displacement of the posteromedial papillary muscle, and tethering of the mitral valve leaflets. Together, these changes prevent proper coaptation of the mitral valve leaflets during systole, ultimately resulting in retrograde flow across the valve. The annular

dilation component of these structural changes has been the most widely recognized aspect of the pathophysiology of FMR. As such, the intent of mitral ring annuloplasty in this setting is to reduce the size of the annulus so that proper coaptation of the leaflets is restored, thereby eliminating regurgitation. This approach is effective in the acute correction of FMR in a majority of patients, and has therefore been the primary surgical method of treating FMR clinically. Unfortunately, it has been associated with rates of recurrent MR as high as 15% to 30%.<sup>7-9</sup>

Currently, both partial (C-ring) and complete (O-ring) annuloplasty rings are used for mitral annuloplasty in patients with FMR. Prior reports have not demonstrated any difference in durability of repair between the 2.<sup>10,11</sup> Accordingly, there are no clear principles that guide the choice of 1 type of ring over another in the clinical practice of most surgeons other than anecdotal information about the superiority of 1 type of ring over the other. A recent retrospective study<sup>12</sup> showed that for patients with degenerative MR, the use of complete, semi-rigid annuloplasty rings was associated with lower rates of recurrent MR compared with partial flexible annuloplasty rings. To date, this has not been investigated specifically in patients with FMR, in whom both the pathophysiology of the MR itself and the operative approach are significantly different. We therefore sought to

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### Abbreviations and Acronyms

FMR	= functional mitral regurgitation
LV EDD index	= Left ventricular end-diastolic dimension index
MR	= mitral regurgitation
SAM	= systolic anterior motion

determine if the rate of recurrence of MR in patients with FMR was affected by the type of ring used.

## METHODS

### Study Design

This study is a retrospective, nonrandomized review of all patients who underwent mitral valve repair using undersized mitral ring annuloplasty as the primary intervention for FMR between 1998 and 2008 at our institution. The study was approved by the internal Institutional Review Board with a waiver for patient consent.

### Patients

A total of 548 patients between October 1998 and December 2008 who underwent mitral valve repair using mitral ring annuloplasty without the use of edge-to-edge Alfieri stitch repair for the diagnosis of FMR were identified in the Society of Thoracic Surgeons database (version 2.52). FMR was defined as the presence of all 3 of the following criteria: a documented diagnosis of ischemic or idiopathic dilated cardiomyopathy; MR by echocardiography not attributable by echocardiographic criteria to degenerative disease; and intraoperative findings from the operative report describing the presence of normal, nondegenerative mitral valve leaflets.

Preoperative clinical data collected include the patient's age, sex, height, weight, calculated body surface area, preoperative New York Heart Association Functional Class, ejection fraction and degree of MR by preoperative echocardiogram, presence of preoperative atrial fibrillation, diabetes mellitus, hypertension, chronic lung disease, chronic renal failure, hyperlipidemia, stroke, peripheral vascular disease, preoperative intra-aortic balloon pump requirement, and the etiology of FMR (ischemic or idiopathic). Left ventricular end-diastolic dimension index (LV EDD Index) was calculated by dividing the measured LV EDD by the calculated patient body surface area.

The primary end point was the incidence of recurrent MR, defined by the presence of moderate-to-severe MR by echocardiography at any postoperative time point within the study period. The final cohort of patients was ultimately composed of 479 total patients for whom postoperative echocardiographic data were available. Among these patients, 270 received partial rings and 209 received complete rings.

### Surgical Management

All patients underwent mitral valve procedures, with or without concomitant heart procedures, performed by 1 of 13 surgeons. Intraoperative echocardiography was performed in all patients before and immediately following mitral valve annuloplasty ring placement. Exposure was provided by median sternotomy for most patients, except for 38 patients (8%) in whom either minimally invasive thoracotomy or hemisternotomy was performed. All procedures were performed with the use of mild systemic hypothermic cardiopulmonary bypass with intermittent crystalloid cardioplegia to provide myocardial protection. Exposure to the mitral apparatus was achieved through a traditional left atrial incision along Sondergaard's groove. Patients received one of three types of partial rings or 1 of 5 types of complete rings. The choice of ring was left to the discretion of the

surgeon at the time of operation. Of note, the Carbomedics Annuloflex ring (Sulzer Carbomedics, Inc, Austin, Tex (division of Sulzer Medica) has the capability of being implanted in partial or complete configuration and is therefore represented in both groups. Rings were downsized in standard fashion by choosing a ring 1 or 2 sizes smaller than predicted by measuring the height of the anterior leaflet.

### Follow-up

Postoperative echocardiographic and clinical data, including postoperative complications and mortality were obtained from the Society of Thoracic Surgeons and departmental databases, institutional electronic medical records, and query of the Social Security Death Index. The primary end point for this study was the postoperative recurrence of MR, defined in this study as either 3+ (moderate) or 4+ (severe) MR at any time point during the study period. 30-day mortality was defined as mortality within 30 days regardless of hospital discharge, whereas operative mortality was defined according to the Society of Thoracic Surgeons definition (ie, mortality within 30 days and/or death before discharge from the index hospitalization).

### Statistical Analysis

Categorical data are expressed as numbers and percentage, and continuous data as means  $\pm$  standard deviation or medians and interquartile range for normally or non-normally distributed data. Categorical variables were compared using the Fisher exact test. Continuous variables were compared using the Student *t* test with the Levine test for homogeneity of variance or Mann-Whitney U test as appropriate.

A risk-matched propensity analysis consisted of a logistic regression analysis. Based on available literature, clinical expertise, patient characteristics, and known operative differences, we selected factors contributing to the likelihood of receiving a complete or partial ring. These were entered into a multivariable forward stepwise logistic regression. Interactions were examined, and the interaction variable between the surgeon and year of surgery was included to control for differences in the patient comorbidity loads and techniques over time. Any variable significant at a *P* value  $\leq .15$  was retained. The resulting adjusted predicted value for each patient was calculated, and a 1:1 complete:partial ring match based on predicted value (nearest thousandth place) was derived. Subsequent analyses were performed on this cohort of 204 subjects (*n* = 102 per group).

Enter-method Cox regression analysis of the unmatched cohort was performed to evaluate if ring type was an independent variable for MR recurrence. Covariates with known associations with greater severity of disease and for which complete data were available were included for analysis.

Survival was estimated by using Kaplan-Meier analyses. Statistical analyses were performed with SPSS version 13.0 (2005; IBM, Armonk, NY).

## RESULTS

### Overall Results

We limited the majority of our analyses to the 479 of 548 subjects with follow-up echocardiographic data available. A responder bias analysis between these subjects and the 69 for whom we lacked postoperative echocardiographic data showed no significant differences with respect to age, sex, preoperative cardiac measures, operative times, or concomitant procedures (data not shown).

Among 479 patients for whom postoperative echocardiographic data were available, Table 1 shows that complete ring recipients had significantly lower preoperative ejection fractions and a higher proportion of patients requiring preoperative intra-aortic balloon pump support compared with partial ring recipients, but were similar with regard to all other

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