

Original
Article

Clinical Outcomes of a Customized Mitral Valve Plasty for Functional Mitral Regurgitation with a Low Ejection Fraction and Implications for Preoperative Right Ventricular Function

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Purpose: To evaluate clinical outcomes of customized mitral valve plasty (MVP) for the treatment of functional mitral regurgitation (FMR) with a low ejection fraction (EF) and to determine which preoperative factors affected the clinical outcome.

Methods and Results: MVP was adjusted according to the degree of left ventricle (LV) remodeling. We performed mitral annuloplasty (MAP) alone in 14 patients and added subvalvular procedures (SVPs) in 22 patients at a high risk of recurrent MR. During follow-up, reverse LV remodeling was obtained and the 3-year and 5-year non-recurrence rates of MR grade ≥ 2 were 94% and 89%, respectively. Two patients died during their hospital stay, and four more patients died of cardiac causes during follow-up. The 3-year and 5-year rates of freedom from cardiac-related mortality were 86% and 81%, respectively; no significant difference was observed between the two treatment groups. Right ventricular fractional area change (RVFAC) was a significant predictor of cardiac mortality. Patients with an RVFAC of $< 26\%$ had significantly poorer cardiac-related mortality (71% at 3 years) than those with an RVFAC of $\geq 26\%$ (95% at 3 years).

Conclusion: Customized MVP provided durable mitral competence and reverse LV remodeling. Preoperative RV function was associated with cardiac-related mortality.

Keywords: functional mitral regurgitation, mitral valve plasty, subvalvular procedure, right ventricular function, RVFAC

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Introduction

Based on a recent randomized controlled trial comparing mitral valve plasty (MVP) with chordae-sparing mitral valve replacement (MVR) for severe functional mitral regurgitation (FMR),^{1,2} the 2017 American Heart Association/American College of Cardiology (AHA/ACC) focused update of the 2014 AHA/ACC guideline for the management of patients with valvular heart disease states that it is reasonable to choose chordae-sparing MVR over MVP for chronic severe FMR.³ However, the optimal surgical treatment for the management of FMR is yet to be confirmed. If MVP for FMR is durable, it

may be a more preferred choice for perioperative mobility, preservation of cardiac function, and avoidance of prosthesis-related complications, and these considerable merits may contribute to long-term survival. Hence, a pathophysiology-guided strategy incorporating subvalvular procedures (SVPs) that optimize the outcomes of patients who are at a high risk of recurrent mitral regurgitation (MR) has been proposed.⁴⁾ However, the results of such a pathophysiology-guided strategy have not yet been reported. We selected mitral valve (MV) surgical procedures based on patients' age, left ventricular (LV) diameter, values of leaflet tethering, and MR severity. We performed MVP adding SVP for patients at a high risk of persistent/recurrent MR. The purpose of this study was to evaluate the clinical characteristics and outcomes of operations for the treatment of FMR with a low ejection fraction (EF) in patients who underwent MVP and to determine which preoperative factors affected clinical outcomes.

Materials and Methods

Patients

We retrospectively analyzed the records of all patients ($n = 36$) who underwent MVP for FMR with an LVEF lower than 40%, at Miyazaki Medical Association Hospital between April 2010 and September 2015 and at Miyazaki University Hospital between October 2015 and December 2018. Nine elderly patients (mean 75 ± 7 years) who underwent MV replacement for moderately severe or severe MR during the same period were excluded from this study. FMR was defined as secondary MR due to myocardial pathologies, such as ischemic cardiomyopathy (ICM), idiopathic dilated cardiomyopathy (DCM), and aortic valve disease. The New York Heart Association (NYHA) functional classification, which is based on symptom severity and the amount of exertion needed to provoke symptoms, was also assessed preoperatively.

The Institutional Review Board at Miyazaki Medical Association Hospital and Miyazaki University Hospital approved this retrospective study. The requirement for individual patient consent was waived because of the retrospective nature of the study. General informed consent was obtained from each patient prior to their operations.

Choice of surgical procedures

MV surgery was performed for symptomatic patients with moderately severe or severe MR. MV surgery was

also performed for symptomatic patients with moderate MR who underwent other cardiac surgeries, like coronary artery bypass grafting (CABG) or aortic valve replacement. In principle, we performed mitral reduction annuloplasty (MAP) alone in patients with non-advanced remodeled LVs. In patients with advanced remodeled LVs (LV end-diastolic dimension [LVDd] >65 mm, LV end-systolic dimension [LVDs] >51 mm, coaptation tenting height [TH] ≥ 11 mm, posterior mitral leaflet angle [PLA] $>45^\circ$, and non-negligible seagull sign) and/or high-grade MR (MR grade 3 or 4), we performed MAP combined with SVPs. SVP included papillary muscle approximation (PMA),⁵⁾ papillary muscle relocation (PMR),⁶⁾ LV reconstruction (LVR),^{7,8)} or secondary chord cutting (SCC).⁹⁾ These operations were performed according to the discretion of the surgeons; we tended to select PMA early in our experience, PMR or SCC as we became more experienced, and PMA or PMR after further experience. LVR was performed in patients with a dilated ICM (LV with an LV end-systolic volume index >80 – 100 mL/m² and a regional asynergy $>35\%$ of the ventricular perimeter). LVR was never performed for DCM.

Surgical technique and follow-up

All procedures were performed through a median sternotomy. The cardiopulmonary bypass was established with cannulation to the ascending aorta, superior vena cava, and inferior vena cava. After aortic cross-clamping, antegrade blood cardioplegic arrest was induced in all patients except for one patient who had a porcelain aorta and for whom the on-pump beating heart technique was used for all procedures. MAP was performed through left atriotomy with a semi-rigid full ring for all patients, except for two patients for whom we used a partially flexible ring instead. The ring using MAP was moderately undersized by 1–2 sizes from the annulus diameter. For PMA that was performed simultaneously with LVR, we approximated the papillary muscles from the base to the middle parts using two pledgeted mattress sutures (3-0 polypropylene) through the LV incision. For PMA that was performed without LVR, we approximated the papillary muscles at the head portions using one pledgeted mattress suture (3-0 polypropylene) through the MV annulus. For PMR, we relocated papillary muscles or the posterior papillary muscle to the mitral fibrous trigone or the mid-septal mitral annulus, respectively, using 2-0 polytetrafluoroethylene. For LVR, the Dor procedure⁷⁾ and septal anterior ventricular exclusion procedure⁸⁾ were

performed. For SCC, we divided the secondary chords that caused the seagull sign on the anterior leaflet. Regardless of the surgical procedures undertaken, total revascularization was performed for patients who had ischemia. All patients were followed up until March 2019. The mean follow-up period was 42 ± 30 months.

Statistical analyses

Means and standard deviations were used to describe data for continuous variables, whereas absolute frequencies and percentages were used for categorical variables. For comparisons between the MAP and SVP groups, Student's t-test was used to compare parametric variables and the Mann–Whitney U test was used to compare nonparametric variables. Baseline-to-follow-up comparisons were performed using Student's t-test for paired samples and the Wilcoxon test. The chi-square test was used for categorical variables. Kaplan–Meier curves were generated to describe freedom from cardiac-related mortality and non-recurrence of MR (grade ≥ 2). Freedom from cardiac-related mortality was compared between the MAP and SVP groups using the Wilcoxon test.

Preoperative factors, transthoracic echocardiographic parameters, and operating factors, such as SVP, CABG or tricuspid annuloplasty were entered into univariate Cox proportional hazards models to identify significant predictors of cardiac death. In the multivariate analysis, right ventricular fractional area change (RVFAC) with a p value <0.05 in univariate analysis, age, and whether CABG or SVP were performed was entered into a Cox multivariable model. Using a cutoff value of RVFAC $<26\%$ vs. $\geq 26\%$ (as reported by Kawata et al.¹⁰), the cumulative survival was compared between patients with preoperative RVFAC of $\geq 26\%$ and $<26\%$ using the Wilcoxon test. A value of p <0.05 was considered statistically significant.

Results

Patient characteristics

Table 1 summarizes the patients' preoperative characteristics. The mean age was 68 ± 10 (range 46–82) years, and 26 patients (72%) were men. Underlying diseases were ICM in 25 patients, DCM in 9 patients, and aortic valve disease in two patients. The mean NYHA functional classification was 3.0 ± 0.7 . The preoperative mean LV end-systolic volume index and LVEF of patients who underwent LVR were 134 ± 56 mL/m² and $24 \pm 7\%$, respectively.

Preoperative echocardiographic parameters

Table 2 presents the preoperative transthoracic echocardiographic parameters. MR was classified as none (grade 0), mild (grade 1), moderate (grade 2), moderately severe (grade 3), or severe (grade 4) by “observation by an experienced operator” or by planimetry of the MR color flow jet area. We assessed RVFAC by tracing the right ventricle (RV) endocardium, in both systole and diastole, from the annulus along the free wall to the apex, and then back to the annulus, and along the inter-ventricular septum to quantify RV function.¹¹ The mean LVDD, LVDs, left atrial dimension (LAD), LVEF, and MR grade were 60 ± 9 mm, 53 ± 9 mm, 43 ± 8 mm, $28 \pm 8\%$, and 2.6 ± 0.7 , respectively. MR was grade 2 in 19 patients (53%), grade 3 in 14 patients (39%), and grade 4 in 3 patients (8%). The mean TH, tenting area (TA), and PLA in the parasternal long-axis view were 9 ± 3 mm, 1.6 ± 0.8 cm², and $45^\circ \pm 11^\circ$, respectively. The RVFAC was $28 \pm 12\%$ and 14 patients (39%) had RVFAC of $<26\%$.

Comparison of preoperative characteristics and transthoracic echocardiographic parameters

Compared with patients in the MAP group, those in the SVP group were significantly younger (72 ± 9 vs 65 ± 9 years; p = 0.04), were more affected by DCM (2/14 vs. 7/22, p <0.01), and had a significantly larger LVDD (54 ± 6 vs. 64 ± 7 mm; p <0.01), larger LVDs (46 ± 8 vs. 56 ± 8 mm; p <0.01), higher TH (7 ± 2 vs. 10 ± 3 mm; p <0.01), larger TA (1.1 ± 0.5 cm² vs. 1.9 ± 0.8 cm²; p <0.01), and a significantly wider PLA ($39^\circ \pm 12^\circ$ vs. $50^\circ \pm 8^\circ$; p <0.01). No significant differences were found between groups in other transthoracic echocardiographic parameters such as LVEF, MR grade, PAP, RVFAC, and the ratio of patients with RVFAC of $<26\%$ (**Tables 1 and 2**).

Operative data

Table 1 shows the surgical details. In all, 14 patients (39%) underwent MAP alone and 22 patients (61%) underwent MAP combined with SVPs. For SVP, we performed PMA in 11 cases, PMR in six cases, LVR in six cases, and SCC in four cases; several procedures were performed in combination. The mean size of the prosthetic mitral ring was 27 ± 2 mm. In all, 17 patients (47%) underwent CABG and received a mean of 2.8 ± 1.0 grafts. Patients who underwent MAP alone underwent CABG exclusively (12/14 vs. 5/22, p <0.01). On the contrary, patients who underwent SVPs tended to undergo tricuspid annuloplasty (15/22 vs. 5/14, p = 0.06).

Table 1 Preoperative characteristics and surgical details of patients

Variable	Total (n = 36)	MAP (n = 14)	SVP (n = 22)	p between groups
Age (years)	68 ± 10	72 ± 9	65 ± 9	0.04
Male (n, %)	26 (72%)	8 (57%)	18 (82%)	0.1
IHD (n, %)	25 (69%)	12 (86%)	12 (55%)	0.053
DCM (n, %)	9 (25%)	2 (14%)	7 (32%)	<0.01
NYHA	3.0 ± 0.7	3.1 ± 0.6	3.0 ± 0.7	0.7
SVP			LVR+PMA:3 LVR+PMR:1 SCC+PMR:1 PMA:8 PMR:4 SCC:3 LVR:2	–
CABG (n, %)	17 (47%)	12 (86%)	5 (23%)	<0.01
AVR (n, %)	5 (14%)	1 (7%)	4 (18%)	0.4
TAP (n, %)	20 (56%)	5 (36%)	15 (68%)	0.06
Maze (n, %)	4 (11%)	0	4 (18%)	0.09
AXCT (min)	108 ± 32	122 ± 27	100 ± 32	0.04
ECC (min)	183 ± 37	183 ± 31	184 ± 42	0.9
Ope (min)	344 ± 70	354 ± 68	337 ± 73	0.6

AVR: aortic valve replacement; AXCT: aortic cross-clamp time; CABG: coronary artery bypass grafting; DCM: idiopathic dilated cardiomyopathy; ECC: extracorporeal circulation time; IHD: ischemic heart disease; LVR: left ventricular reconstruction; MAP: mitral annuloplasty; NYHA: New York Heart Association classification; Ope: operation time; PMA: papillary muscle approximation; PMR: papillary muscle relocation; SCC: secondary chords cutting; SVP: subvalvular procedure; TAP: tricuspid annuloplasty

Clinical outcomes and changes in echocardiographic parameters

None of the patients who underwent LVR died during hospitalization; the postoperative LV end-systolic volume index decreased to 86 ± 38 mL/m² and LVEF improved to $34 \pm 10\%$.

A total of two patients (5.5%), one patient (7%) in the MAP group and one patient (4.5%) in the SVP group, died during hospitalization. Of these, one died of low-output syndrome, and one died of pneumonia. Six patients died during the follow-up period. Of these, two died of cancer, and four died of cardiac causes (low-output syndrome in three patients and sudden death in one patient). **Figure 1** shows the curve for freedom from cardiac-related mortality. The 3-year and 5-year rates of freedom from cardiac-related mortality, including in-hospital death, were 86% and 81%, respectively.

During the most recent follow-up period (42 ± 30 months post-surgery), the postoperative transthoracic echocardiographic parameters of all patients (including one who had undergone additional MV surgery) had improved significantly compared with the preoperative values, except for LAD. The MR grade (0.7 ± 0.9) improved significantly compared with the preoperative

grade (2.6 ± 0.7) ($p < 0.01$). Four patients (12%) experienced a recurrence of MR grade ≥ 2 , and the 3-year and 5-year non-recurrence of MR grade ≥ 2 rates were 94% and 89%, respectively (**Table 2**).

Comparison of therapeutic effects on echocardiographic parameters and clinical outcomes

In the MAP group, one patient (7%) experienced recurrence of MR grade ≥ 2 , LVDs (from 46 ± 8 to 37 ± 12 mm; $p < 0.01$) significantly decreased, and LVEF (from $29 \pm 7\%$ to $46 \pm 18\%$; $p = 0.01$) significantly improved. In the SVP group, three patients (14%) experienced recurrence of MR grade ≥ 2 , and one patient underwent MV replacement 56 months after the first surgery. The 3-year and 5-year non-recurrence rates of MR grade ≥ 2 were 95% and 76%, respectively. LVDd (from 64 ± 7 to 59 ± 9 mm; $p < 0.01$), LVDs (from 56 ± 8 to 49 ± 11 mm; $p < 0.01$), and LAD (from 44 ± 8 to 41 ± 5 mm; $p = 0.03$) significantly decreased, and the LVEF (from $27 \pm 8\%$ to $36 \pm 14\%$; $p = 0.02$) significantly improved (**Table 2**).

One patient in the MAP group and five patients in the SVP group died of cardiac causes after surgery and during follow-up. **Figure 1b** shows the curve for freedom from cardiac-related mortality comparing the MAP group and

Table 2 Comparison of transthoracic echocardiogram parameters

Parameter	All			MAP			SVP		
	Preope	During follow-up	p between groups	Preope	During follow-up	p between groups	Preope	During follow-up	p between groups
LVDd (mm)	60 ± 9	55 ± 10	<0.01	54 ± 6*	49 ± 9*	0.08	64 ± 7*	59 ± 9*	<0.01
LVDs (mm)	53 ± 9	44 ± 13	<0.01	46 ± 8*	37 ± 12*	<0.01	56 ± 8*	49 ± 11*	<0.01
LAD (mm)	43 ± 8	40 ± 5	0.06	41 ± 8	39 ± 6	0.9	44 ± 8	41 ± 5	0.03
LVEF (%)	28 ± 8	40 ± 16	<0.01	29 ± 7	46 ± 18	0.01	27 ± 8	36 ± 14	0.02
MR grade	2.6 ± 0.7	0.7 ± 0.9	<0.01	2.5 ± 0.7	0.8 ± 1.1	<0.01	2.6 ± 0.7	0.7 ± 0.8	<0.01
MR ≥2 (n, %)	36 (100)	4 (12)	<0.01	14 (100)	1 (7)	<0.01	22 (100)	3 (14)	<0.01
PAP (mmHg)	43 ± 14	–	–	48 ± 16	–	–	40 ± 12	–	–
TH (mm)	9 ± 3	–	–	7 ± 2*	–	–	10 ± 3*	–	–
TA (cm ²)	1.6 ± 0.8	–	–	1.1 ± 0.5*	–	–	1.9 ± 0.8*	–	–
PLA (degree)	45 ± 11	–	–	39 ± 12*	–	–	50 ± 8*	–	–
RVFAC (%)	28 ± 12	–	–	32 ± 12	–	–	26 ± 12	–	–
RVFAC <26% (n, %)	14 (39)	–	–	6 (43)	–	–	8 (36)	–	–

LAD: left atrium dimension; LVEF: left ventricular ejection fraction; LVDd: left ventricular diastolic dimension; LVDs: left ventricular systolic dimension; MAP: mitral annuloplasty; MR: mitral regurgitation; PAP: pulmonary artery systolic pressure; PLA: posterior leaflet tethering angle; Preope: preoperative; RVFAC: right ventricular fractional area change; SVP: subvalvular procedure; TA: tenting area; TH: tenting height. *p <0.05 between MAP and SVP group

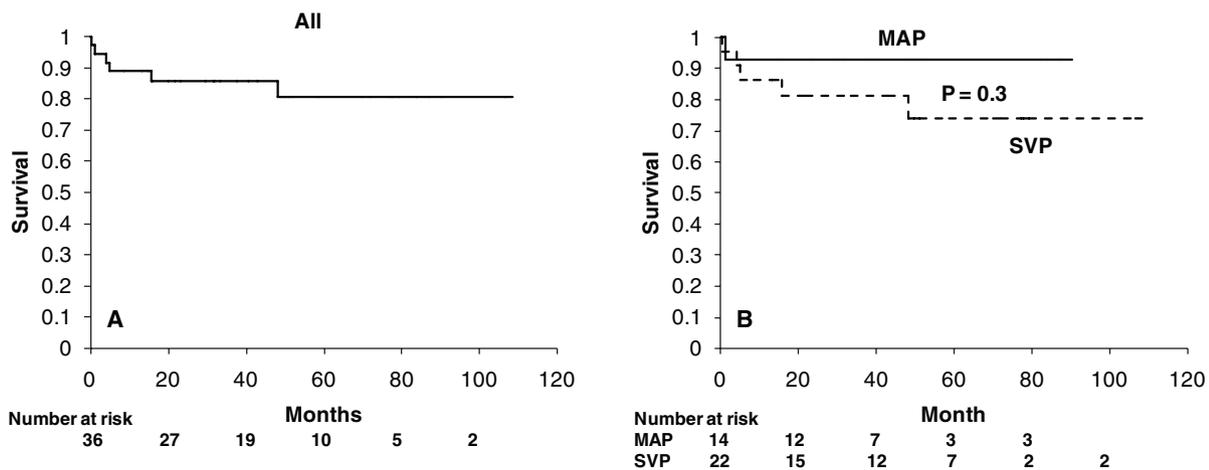


Fig. 1 The survival curve for cardiac-related mortality. (A) The 3-year and 5-year rates of freedom from cardiac-related mortality for all patients were 86% and 81%, respectively. (B) The 3-year and 5-year rates of freedom from cardiac-related mortality in the MAP group were 93% and 93%, respectively, and those in the SVP group were 81% and 74%, respectively (p = 0.3). MAP: mitral annuloplasty; SVP: subvalvular procedure

SVP group. No significant difference in freedom from cardiac-related mortality was observed between the groups. The 3-year rate of freedom from cardiac-related mortality in the MAP group was 93%, and that in the SVP group was 81% (p = 0.3).

Risk factor analysis for cardiac-related mortality

Table 3 presents the univariate and multivariate Cox proportional hazards models for cardiac-related mortality. The RVFAC was the only significant predictor of cardiac-related mortality in the univariate analysis (risk

ratio [RR] = 0.88, 95% confidence interval [CI]: 0.78–0.97, p < 0.01) and the multivariate analysis (RR = 0.89, 95% CI: 0.76–0.98, p = 0.02).

Comparison of clinical outcomes in patients with preoperative RVFAC of ≥26% and <26%

Figure 2 shows the curve for freedom from cardiac-related death comparing the patients with a preoperative RVFAC of ≥26% (n = 22) and <26% (n = 14). A significant difference was observed between the groups. The 3-year rate of freedom from cardiac-related mortality in patients

Table 3 Risk factor analysis for cardiac-related death

Variable	Univariate analysis			Multivariate analysis		
	RR	95% CI	p value	RR	95% CI	p value
Age	1.06	0.97–1.17	0.2	1.08	0.99–1.21	0.1
DCM	0.6	0.03–3.74	0.6			
LVDd	1.03	0.94–1.14	0.5			
LVDs	1.03	0.95–1.12	0.5			
LAD	1.08	0.98–1.21	0.1			
PAP	1.03	0.97–1.09	0.4			
MR			0.5			
LVEF	0.99	0.90–1.12	0.9			
TH	1.51	0.09–17	0.8			
PLA	1.05	0.97–1.16	0.3			
RVFAC	0.88	0.78–0.97	<0.01	0.89	0.76–0.98	0.02
SVP	3.18	0.51–61	0.24	1.13	0.10–28	0.9
CABG	0.35	0.05–1.83	0.2	0.31	0.03–1.85	0.2
TAP	4.06	0.65–77	0.1			

CABG: coronary artery bypass grafting; CI: confidence interval; DCM: idiopathic dilated cardiomyopathy; LAD: left atrium dimension; LVEF: left ventricular ejection fraction; LVDd: left ventricular diastolic dimension; LVDs: left ventricular systolic dimension; MR: mitral regurgitation; PAP: pulmonary artery systolic pressure; PLA: posterior leaflet tethering angle; RR: risk ratio; RVFAC: right ventricular fractional area change; SVP: subvalvular procedure; TAP: tricuspid annuloplasty; TH: tenting height

with RVFAC of $\geq 26\%$ was 95%, and that in patients with RVFAC of $< 26\%$ was 71% ($p = 0.03$) (Fig. 2).

Discussion

Our results showed that MVP, customized according to the degree of remodeling progression, provided durable mitral competence associated with reverse LV remodeling. Preoperative RV function was associated with cardiac-related mortality.

We performed MAP in non-advanced remodeling cases and added SVPs to MAP in cases of advanced remodeling. As a result, the recurrence rates of MR appeared to be favorable compared with those reported by recent studies involving MAP alone for FMR, in which 2-year or 5-year rates of non-recurrence of MR were approximately 42%–58%.^{2,12,13} Moreover, LV reverse remodeling progressed even in the SVP group. As recurrent MR after MVP is associated with progressive LV remodeling, durable mitral competence after customized MVP must contribute to LV reverse remodeling.^{2,14–16} This is in line with the findings of a systematic review on SVP by Mihos et al. and Athanasopoulos et al.^{17,18} Although we used several different SVPs and recognized the advantages and disadvantages of each technique, the different SVPs would offer similar mitral competence.^{18,19}

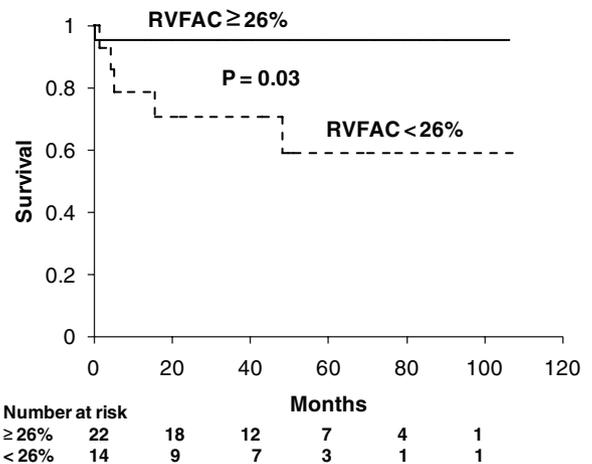


Fig. 2 The survival curve for cardiac-related mortality in patients with preoperative RVFAC of $\geq 26\%$ and $< 26\%$. The 3-year and 5-year rates of freedom from cardiac-related mortality in patients with RVFAC of $\geq 26\%$ were 95% and 95%, respectively, and that in patients with RVFAC of $< 26\%$ were 71% and 59%, respectively ($p = 0.03$). RVFAC, right ventricular fractional area change

On the contrary, it is difficult to interpret whether the long-term mitral durability and reverse LV remodeling due to customized MVP also contributed to the improved survival in FMR because we did not have any comparative target. The 3-year and 5-year rates of freedom from

cardiac-related mortality were 86% and 81%, respectively. In the SVP group, the 3-year and 5-year rates of freedom from cardiac-related mortality were 81% and 74%, respectively. These rates might not be superior or even equivalent to those reported in studies with more frequently recurring MR, in which 2-year or 5-year rates of freedom from cardiac-related mortality were approximately 71%–81%.^{2,12,13)}

The Cardiothoracic Surgical Trials Network randomized study recruited 301 patients and concluded that adding MVP to a CABG did not show significant advantages in major adverse cardiac or cerebrovascular events, deaths, readmissions, functional status, or quality of life at 1 year, though MVP reduced the prevalence of moderate or severe MR compared with CABG alone.²⁰⁾ A systematic review and meta-analysis by Mihos et al. and a prospective randomized trial by Nappi et al. demonstrated that adding SVP to MAP for ischemic MR was associated with greater LV reverse remodeling and less recurrence of moderate or greater MR than those achieved by MAP alone; however, no difference was found in the mortality rate.^{12,17)} Therefore, it is unclear whether achieving good mitral competence following elaborate MV surgery always guarantees improved survival in FMR.

In our study, preoperative RVFAC to quantify RV function was a significant predictor of cardiac death. RV dysfunction is a well-known predictor of chronic heart failure.^{21–23)} We also reported the effect of RV function on mid-term outcomes after LVR for a dilated ICM.²⁴⁾ However, only limited data are available on the influence of RV function on outcomes after MVP for FMR.

Most commonly, RV failure is a consequence of increased RV afterload in the context of pulmonary hypertension due to LV dysfunction. Therefore, the correction of MR by MV surgery may improve RV function and mitigate the relationship between RV dysfunction and mortality.²⁵⁾ However, RV dysfunction in left-sided heart failure does not simply result from pulmonary venous and arterial hypertension due to LV chronic dysfunction because RV systolic function is the result of a complex interaction with the remodeled and enlarged LV, LV septal function, LV myocardial function, and PAP with or without MR.²⁶⁾ Therefore, RV systolic dysfunction is a potent prognostic marker of outcome in left-sided heart failure.^{24,26,27)}

We used RVFAC as the only measure to quantify RV function in this study; RVFAC is one of the recommended parameters to quantitatively estimate the RV function with prognostic value.¹¹⁾ Combining more than one

measure of RV function, such as RVFAC, tricuspid annular plane systolic excursion (TAPSE), and tissue Doppler-derived tricuspid lateral annular systolic velocity (S') may more reliably distinguish normal from abnormal function, since there is not yet a single universally accepted echocardiographic parameter for the assessment of the RV.¹¹⁾ However, RVFAC may reflect disease severity more accurately than TAPSE or S' in patients with advanced heart failure because RVFAC includes radial as well as longitudinal shortening whereas both TAPSE and S' are only longitudinal systolic parameters.¹⁰⁾

Di Maruo et al.²⁸⁾ reported RV function as an independent predictor of survival in patients with ICM or DCM after MV surgery. Furthermore, findings from percutaneous MV repair using MitraClip suggest that patients with chronic heart failure and RV dysfunction had worse functional capacity and showed unfavorable long-term outcomes.^{29,30)} Therefore, patients with preoperative severe RV dysfunction may be unlikely to benefit from MV surgery concerning long-term prognosis; refraining from MV surgery and alternative therapies such as ventricular assist devices or heart transplant should be considered if the patients are deemed to have end-stage heart failure.

Limitations

This study had several limitations. There were no clear criteria available that facilitated the selection of any SVP other than LVR; however, any SVP provided durable mitral competence. It might not be appropriate to classify LVR without PMR, PMA, or SCC as a subvalvular repair. However, we believe that LVR favorably affects the LV reverse-remodeling process by MAP and results in favorable mitral competence. Which is the better choice, MV replacement or MAP combined with SVPs for the treatment of FMR with advanced remodeled LVs, is of major concern. However, this issue was not considered in this study because MV replacement was performed for only nine elderly patients with high-grade MR. This was a retrospective study performed in a small number of patients with heterogeneity in surgical technique as well as patient background. In particular, half of the patients were in grade 2 MR because of preoperative aggressive medication. These facts did not allow for a direct comparison with larger studies, which limited the validity of our results. Therefore, studies with larger sample sizes are required to confirm the current findings.

Conclusions

MVP, customized according to the degree of remodeling progression, provided durable mitral competence and reverse LV remodeling. Preoperative RV function was associated with cardiac-related mortality. Patients without severe RV dysfunction can be good candidates for MV surgery. Conversely, patients with severe RV dysfunction may not be good candidates for MV surgery concerning the long-term prognosis.

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Disclosure Statement

The authors declare that they have no conflicts of interest.

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