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The Clinical Outcome of Maze Procedure in Atrial Functional Mitral Regurgitation

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Atrial functional mitral regurgitation (AFMR) is a newly discovered condition associated with long-standing atrial fibrillation (AF). This retrospective study analyzed the outcomes of the maze procedure and mitral regurgitation surgery in patients with AFMR and compared them with those in patients without AFMR. Patients who underwent the maze procedure at a single center were included (July 2012-August 2021). After excluding patients aged <18 years and those with infective endocarditis, 36 patients with AFMR (AFMR group) and 248 without AFMR (non-AFMR group) were enrolled in the study. The outcomes were compared using propensity score matching (PSM). After PSM, there were 36 patients in each group. The rates of freedom from AF at 1, 3, and 5 years postoperatively were 64.5%, 62.5%, and 60.0%, respectively, in the AFMR group, and were not significantly different from those in the non-AFMR group (p = 0.07). However, significantly more patients with AFMR exhibited junctional rhythm after the maze procedure than those without AFMR (p = 0.001) and significantly more underwent permanent pacemaker insertion in the AFMR group than in the non-AFMR group (p = 0.021). The groups demonstrated no significant differences in cardiac operation results. Patients with AFMR required close observation for sinus nodal dysfunction with bradycardia after the maze procedure. However, the results of cardiac surgery, including mitral valve repair, were comparable to those in patients without AFMR.

Keywords: Atrial fibrillation, Maze procedure, Mitral valve insufficiency

Introduction

Atrial functional mitral regurgitation (AFMR) is a type of mitral regurgitation (MR) with normal leaflet motion. AFMR is usually combined with long-standing atrial fibrillation (AF) [1], as a result of left atrial (LA) dilatation with mitral annulus dilation [2]. The reported incidence of AFMR is 4% to 8% in patients with persistent AF, but its prevalence increases to 28% in patients with longstanding AF [3,4].

The management of patients with AFMR is not well established in large part because of a lack of data [1], but restoration of normal sinus rhythm is an important goal of treatment to reduce MR severity and improve patient prognosis [2]. Although surgical ablation (maze procedure) is another key treatment option for patients with AFMR, the outcomes of the maze procedure in these patients remain unknown. Therefore, we investigated the long-term results of the maze procedure in patients with AFMR who underwent concomitant cardiac surgery and compared them with those in patients without AFMR who also underwent the maze procedure.

Methods

Ethical statement

This study complied with the principles of the Declaration of Helsinki. This study was approved by the Institutional Review Board (approval number: 2023-04-042, April 25, 2023). The requirement for informed consent was waived due to the retrospective nature of the study.

Patient population

This study included patients who underwent the maze procedure using cryoablation (CryoICE Cryoablation Probes; AtriCure) with or without concomitant cardiac surgery at a single medical center from July 2012 to August 2021. We excluded patients aged below 18 years as well as those with infective endocarditis. The remaining patients were divided into two cohorts: patients with AFMR (AFMR group) and those without (non-AFMR group).

Operative techniques and maze procedure

The surgical indications for MR were based on recent guidelines [5]. We performed mitral valve (MV) surgery in patients with severe symptoms or progressive deterioration of cardiac function despite optimal medical therapy. Most patients in this study underwent the maze procedure via complete sternotomy. The techniques for valve replacement, valve repair, and coronary artery bypass grafting differed depending on the surgical period and the surgeon's preference. A modified Cox maze procedure using an argon-based flexible cryoprobe was performed for antegrade or retrograde cardioplegia. The maze procedure was performed with or without LA appendage obliteration according to the patient's medical history and transthoracic echocardiography (TTE) results. Regarding cardiac surgery for MR, we first attempted MV repair rather than replacement. We used a complete, rigid ring for MV repair to restore the coaptation of the MV leaflets and the structure of the dilated annulus.

Criteria of AFMR

We defined AFMR criteria based on recent journal articles [1,3,4,6]. All patients were divided into the AFMR and degenerative MR (DMR) groups according to their preoperative TTE and operative records. The criteria of AFMR were as follows: normal left ventricle (LV) size, geometry (LV volume ≤85 mL/m^2 [male] or ≤78 mL/m^2 [female]), and shape; preserved regional and global function (LV ejection fraction ≥50%); dilated LA size (LA volume index ≥40 mL/m^2 and LA diameter ≥40 mm on the maximal anteroposterior diameter of the LA measured with M-mode at ventricular end-systole); annular dilation and flattening with normal leaflet motion (Carpentier type I MR). Conversely, Carpentier type II MR (billowing, flail leaflets, or chord rupture without rheumatic heart disease or endocarditis) indicated DMR.

Data collection and follow-up

All patient characteristics and outcome data were extracted from the electronic medical records at our medical center. Preoperative TTE was performed most proximate prior to the surgery. We routinely performed TTE before discharge from the hospital and 1 year after surgery, which was defined as postoperative TTE and 1 year follow-up TTE, respectively. Early mortality was defined as mortality within 30 days after surgery.

During the postoperative hospitalization period, daily monitoring was performed using typical 12-channel surface electrocardiography (ECG). During the follow-up period, ECG was performed in the outpatient clinic at 1, 3, and 6 months postoperatively, and then every 6 months thereafter. No AF recurrence on at least two consecutive ECGs indicated sinus rhythm restoration. All other rhythms, including AF, atrial flutter, ectopic atrial arrhythmia, junctional rhythm, and cardiac rhythm of a permanent pacemaker without atrioventricular synchrony, were defined as sinus rhythm restoration failures.

Outcomes

The primary outcomes of the maze procedure were freedom from AF and sinus rhythm restoration. Secondary outcomes were MR recurrence after MV repair; early mortality; freedom from major adverse cardiac events (MACE), including cerebral infarction, readmission for heart failure, permanent pacemaker insertion, cardiac mortality, and radiofrequency catheter ablation.

Statistical analysis

Normally distributed variables were presented as means and compared using independent t-tests. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test and presented as numbers (percentages). Continuous variables were compared using a 2-sample t-test. All statistical tests were two-sided, with an alpha level of 0.05.

The Kaplan-Meier method with the log-rank test was used to estimate the rates of freedom from MACE, all-cause mortality, and the MR recurrence rate. Cox proportional hazards regression was used to identify the predictors of the maze

procedure outcomes (freedom from AF and maintenance of sinus rhythm). Variables with *p*-values <0.2 in the univariable analysis were considered in the multivariable analysis [7]. The backward elimination method was used for model selection in the multivariable analysis. The results were reported as hazard ratios (HRs) and 95% confidence intervals (CIs).

Propensity score analysis was used to adjust for baseline differences between the two groups. Prespecified covariates (Table 1) were included in the propensity score calculation. Patients in the non-occlusion and occlusion groups were matched in a 1:1 manner using nearest-neighbor matching. After propensity score matching, the balance between the two groups was assessed by calculating the standardized mean difference between selected variables; those with a standard-

Table 1. Patient characteristics (before propensity score matching)

	AFMR (n = 36)	Non-AFMR (n = 248)	*p*-value
Sex, male (%)	16 (44.4)	121 (48.8)	0.67
Age (yr)	66.4 ± 9.1	63.3 ± 9.8	0.08
Body surface area (%)	1.68 ± 0.18	1.66 ± 0.19	0.52
Mechanical valve replacement (%)	3 (8.3)	64 (25.8)	0.02*
Rheumatic heart disease (%)	0 (0)	113 (45.6)	<0.001*
Concomitant operation			
Left atrial appendage obliteration (%)	13 (36.1)	98 (39.5)	0.74
Mitral valve replacement (%)	5 (13.9)	101 (40.7)	0.002*
Mitral annuloplasty (%)	31 (86.1)	57 (23.0)	<0.001*
Tricuspid annuloplasty (%)	25 (69.4)	121 (48.8)	0.02*
Aortic valve replacement (%)	3 (8.3)	44 (17.7)	0.16
Aortic valve repair (%)	1 (2.8)	6 (2.4)	0.89
Coronary artery bypass grafting (%)	4 (11.1)	20 (8.1)	0.52
Aortic replacement (%)	0 (0)	13 (5.2)	0.38
ASD or PFO repair (%)	2 (5.6)	22 (8.9)	0.75
Cardiac myxoma removal (%)	0 (0)	3 (1.2)	>0.99
Patent ductus arteriosus repair (%)	0 (0)	2 (0.8)	>0.99
Atrial fibrillation type			
Paroxysmal (%)	0 (0)	65 (26.2)	
Persistent (%)	36 (100)	186 (75.0)	<0.001*
Fine fibrillatory wave (<0.5 mm) (%)	21 (58.3)	132 (53.2)	0.52
Heart failure (%)	13 (36.1)	74 (29.8)	0.42
Coronary artery disease (%)	6 (16.7)	21 (8.5)	0.11
Stroke (%)	3 (8.3)	49 (19.8)	0.10
Peripheral artery disease (%)	0 (0)	4 (1.6)	>0.99
Diabetes on medication (%)	3 (8.3)	52 (21.0)	0.11
Aortic disease (%)	0 (0)	5 (2.0)	>0.99
Hypertension (%)	16 (44.4)	95 (38.3)	0.45
COPD (%)	0 (0)	5 (2.0)	>0.99
Chronic kidney disease (%)	3 (8.3)	17 (6.9)	0.73
Preoperative TTE			
Ejection fraction (%)	55.7 ± 10.4	54.7 ± 12.0	0.62
LVEDD (cm)	5.4 ± 0.6	5.28 ± 0.83	0.33
Left atrial volume index (mL/m^2)	128.0 ± 55.9	113.6 ± 69.0	0.23
Left ventricular volume index (mL/m^2)	60.9 ± 16.5	63.7 ± 27.8	0.67
Left atrial diameter (cm)	6.0 ± 0.9	5.5 ± 1.0	0.006*

Values are presented as mean ± standard deviation or number (%).
AFMR, atrial functional mitral regurgitation; ASD, atrial septal defect; PFO, patent foramen ovale; COPD, chronic obstructive lung disease; TTE, transthoracic echocardiography; LVEDD, left ventricular end-diastolic diameter.
*Statistically significant.

ized mean difference of <0.20 were considered to have an appropriate balance (Supplementary Fig. 1). Continuous variables were compared using the paired t-test, and categorical variables were compared using the McNemar test. Statistical analyses were performed using SPSS software (version 29.0; IBM Corp.) and R statistical software version 4.0.2 (R Foundation for Statistical Computing).

Results

Patient characteristics

Overall, 36 patients with AFMR (mean age, 66.4 years) and 248 without (non-AFMR mean age, 63.3 years) met the inclusion criteria. Regarding the baseline characteristics before propensity score matching, the non-AFMR group had significantly more rheumatic heart disease (45.6% vs. 0%, $p < 0.001$), mitral annuloplasty (86.1% vs. 23.0%; $p < 0.001$), tricuspid annuloplasty (69.4% vs. 48.8%; $p = 0.02$), and persistent AF (100% vs. 75.0%; $p < 0.001$) than the AFMR group, whereas the LA diameter was significantly larger in the AFMR group than in the non-AFMR group (6.0 ± 0.9 cm vs. 5.5 ± 1.0 cm; $p = 0.006$) (Table 1).

After propensity score matching, 212 patients in the non-AFMR group were excluded, leaving 36 patients in each group. The comparison of characteristics between groups after propensity score matching revealed significantly more rheumatic heart disease (41.7% vs. 0%; $p < 0.001$) in the non-AFMR group, while the AFMR group had significantly more cases of mitral annuloplasty (86.1% vs. 38.9%; $p < 0.001$) and a significantly larger LA diameter (6.0 ± 0.9 cm vs. 5.9 ± 1.1 cm; $p = 0.02$) than that in the non-AFMR group (Table 2).

Outcomes

After propensity score matching, immediate postoperative results were not significantly different between the groups (Table 3). However, the rario of freedom from AF at 1, 3, and 5 years postoperatively were 64.5%, 62.5%, and 60.0% in the AFMR group and 82.4%, 80.8%, and 72.5% in the non-AFMR group, respectively ($p = 0.07$) (Fig. 1). Postoperatively, the maintenance of normal sinus rhythm was significantly more common in the non-AFMR group than in the AFMR group ($p = 0.006$), whereas the junctional rhythm after the maze procedure was significantly more common in patients with AFMR than in those without ($p = 0.001$).

Multivariate analysis of factors for freedom from AF after the maze procedure revealed that paroxysmal AF on preoperative ECG was a significant risk factor for AF recurrence (odds ratio [OR]: 0.552, 95% CI: 0.308-0.987; $p = 0.05$) (Table 4). Furthermore, multivariate analysis showed that AFMR (OR: 17.408, 95% CI: 4.167-72.732; $p < 0.001$), age (OR: 1.088, 95% CI: 1.026-1.153; $p = 0.005$), ejection fraction (OR: 1.061, 95% CI: 1.013-1.111; $p = 0.01$), and rheumatic heart disease (OR: 4.039, 95% CI: 1.061-15.367; $p = 0.04$) were significant risk factors for junctional rhythm following the maze procedure (Table 5).

The rates of freedom from MACE at 1, 3, and 5 years postoperatively were 88.5%, 78.3%, and 61.0% in the AFMR group and 100%, 100%, and 93.4% in the non-AFMR group, respectively; the difference between the groups was significant ($p = 0.004$) (Fig. 2). The details of MACE, freedom from stroke ($p = 0.302$), and readmission for heart failure ($p = 0.117$) after surgery were not significantly different between the two groups. However, significantly more patients with AFMR required permanent pacemaker insertion after the operation compared with the non-AFMR group ($p = 0.021$). Multivariate analysis revealed that junctional rhythm during the follow-up period was a significant risk factor for pacemaker insertion after the maze procedure (HR: 2.849, 95% CI: 1.112-7.299; $p = 0.03$) (Supplementary Table 1).

Results of mitral annuloplasty

In the total cohort, 31 patients (86.1%) in the AFMR group and 57 patients (23.0%) in the non-AFMR group underwent mitral annuloplasty for MR repair. The rates of freedom from MR recurrence (more-than-moderate MR) after mitral annuloplasty at 1, 3, and 5 years postoperatively were 93.3%, 93.3%, and 87.1% in the AFMR group and 96.2%, 96.2%, and 80.1% in the non-AFMR group, respectively, showing no significant difference between the two groups (log rank = 0.72) (Fig. 3). During the follow-up period, severe MR recurred in one patient with AFMR (1 week postoperatively) who underwent redo-MV replacement one month after the first surgery.

In the sub-analysis, we compared the long-term results of MV repair in AFMR and degenerative MV regurgitation in the entire cohort. In the total cohort, before propensity score matching, 42 patients underwent MV repair using the maze procedure for DMR and AF. The long-term results of freedom from recurrence of MV regurgitation after MV repair were not significantly different between patients with AFMR and those with DMR (log rank = 0.512) (Fig. 4).

Discussion

The efficacy of the maze procedure and the effect of MR

Table 2. Patient characteristics (after propensity score matching)

	AFMR (n = 36)	Non-AFMR (n = 248)	*p*-value
Sex, male (%)	16 (44.4)	15 (41.7)	0.81
Age (yr)	66.4 ± 9.1	65.5 ± 8.4	0.13
Body surface area (%)	1.68 ± 0.18	1.65 ± 0.17	0.83
Mechanical valve replacement (%)	3 (8.3)	7 (19.4)	0.31
Rheumatic heart disease (%)	0 (0)	15 (41.7)	< 0.001*
Concomitant operation			
Left atrial appendage obliteration (%)	13 (36.1)	10 (27.8)	0.45
Mitral valve replacement (%)	5 (13.9)	13 (36.1)	0.06
Mitral annuloplasty (%)	31 (86.1)	14 (38.9)	< 0.001*
Tricuspid annuloplasty (%)	25 (69.4)	25 (69.4)	> 0.99
Aortic valve replacement (%)	3 (8.3)	1 (2.8)	0.61
Aortic valve repair (%)	1 (2.8)	2 (5.6)	> 0.99
Coronary artery bypass grafting (%)	4 (11.1)	4 (11.1)	> 0.99
Aortic replacement (%)	0 (0)	0 (0)	
ASD or PFO repair (%)	2 (5.6)	3 (8.3)	> 0.99
Cardiac myxoma removal (%)	0 (0)	0 (0)	
Patent ductus arteriosus repair (%)	0 (0)	0 (0)	
Atrial fibrillation type			
Paroxysmal (%)	0 (0)	0 (0)	
Persistent (%)	36 (100)	36 (100)	> 0.99
Fine fibrillatory wave (< 0.5 mm) (%)	21 (58.3)	20 (55.6)	> 0.99
Heart failure (%)	13 (36.1)	15 (51.7)	0.62
Coronary artery disease (%)	6 (16.7)	7 (19.4)	0.76
Stroke (%)	3 (8.3)	3 (8.3)	> 0.99
Peripheral artery disease (%)	0 (0)	0 (0)	> 0.99
Diabetes on medication (%)	3 (8.3)	5 (13.9)	0.45
Aortic disease (%)	0 (0)	0 (0)	
Hypertension (%)	16 (44.4)	18 (50.0)	0.64
COPD (%)	0 (0)	0 (0)	
Chronic kidney disease (%)	3 (8.3)	2 (5.6)	> 0.99
Preoperative TTE			
Ejection fraction (%)	55.7 ± 10.4	57.3 ± 11.4	0.72
LVEDD (cm)	5.4 ± 0.6	5.3 ± 0.9	0.37
Left atrial volume index (mL/m^2)	128.0 ± 55.9	127.5 ± 70.8	0.09
Left ventricular volume index (mL/m^2)	60.9 ± 16.5	66.4 ± 27.9	0.31
Left atrial diameter (cm)	6.0 ± 0.9	5.9 ± 1.1	0.02*

Values are presented as mean ± standard deviation or number (%).
AFMR, atrial functional mitral regurgitation; ASD, atrial septal defect; PFO, patent foramen ovale; COPD, chronic obstructive lung disease; TTE, transthoracic echocardiography; LVEDD, left ventricular end-diastolic diameter.
*Statistically significant.

surgery on hemodynamics in patients with atrial fibrillation (AFMR) are not well established. Our study had three important findings. First, more patients with AFMR exhibited junctional rhythm after the maze procedure than did those without AFMR, which is associated with pacemaker insertion. Second, the long-term survival of patients with AFMR was not worse than that of patients without AFMR. Third, the MR repair outcomes in patients with AFMR were as good as those in patients without AFMR, especially those with DMR.

In this study, we found that significantly more patients developed a junctional rhythm after undergoing the maze procedure, which was associated with a higher incidence of permanent pacemaker insertion for sinus nodal dysfunction during the follow-up period. AFMR occurs in 2.4% to 66.7%

Table 3. Immediate postoperative results

	AFMR (n = 36)	Other (n = 36)	*p*-value
Bleeding control (< 24 h)	1 (2.8)	2 (5.6)	> 0.99
Early mortality (< 30 days)	3 (8.3)	1 (2.8)	0.61
Hospital stay (day)	16.4 ± 8.3	17.3 ± 14.6	0.78
Follow-up period (mon)	41.6 ± 28.6	52.2 ± 31.7	0.15
Immediate postoperative TTE			
LVEDD (cm)	5.20 ± 0.51	5.14 ± 0.74	0.70
Ejection fraction (%)	55.3 ± 9.4	54.8 ± 13.6	0.84
Left atrial diameter (cm)	5.4 ± 0.8	5.3 ± 0.8	0.66
Left ventricular volume index (mL/m^2)	96.3 ± 24.9	110.31 ± 54.3	0.19
Left atrial volume index (mL/m^2)	55.8 ± 10.4	179.3 ± 9.4	0.94

AFMR, atrial functional mitral regurgitation; TTE, transthoracic echocardiography; LVEDD, left ventricular end-diastolic diameter.
*Statistically significant.

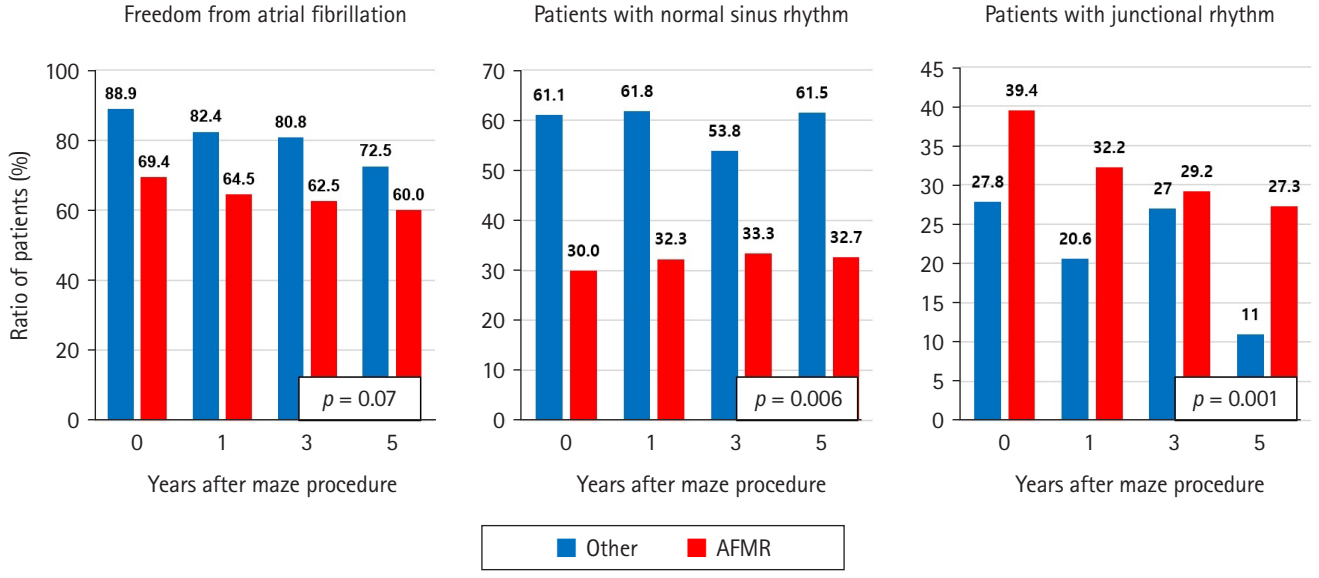

Fig. 1. Maze procedure outcomes. AFMR, atrial functional mitral regurgitation.

of patients with AF [2,8], and its prevalence increases in proportion with the duration of AF [8]. Although Wagner et al. [9] reported that 61% of patients with AFMR maintained a normal sinus rhythm at their latest follow-up after the maze procedure, they had a high risk of developing sinus nodal dysfunction because the effects of longstanding AF include diffuse atrial remodeling with extensive loss of automatic pacemaker tissue and widespread sinoatrial conduction impairment [10,11]. Therefore, patients with AFMR are at a high risk of prolonged AF after the maze procedure because of impaired atrial conduction and extensive pacemaker tissue loss, which leads to junctional rhythm.

In previous studies, the 5-year survival rate for AFMR after MV surgery was 74% to 82% [9,12], which was similar to our results. This suggests that survival and outcomes of the MV surgery in patients with AFMR are comparable to the results in patients with DMR, which has reported rates of postoperative mortality of 77% to 90% [13,14]. Some studies have supported the long-term outcomes of the surgical treatment of AFMR, and the prognosis for patients with AFMR appears to be as good as that for patients with DMR [15-19]. However, the outcomes were better than those of patients with ventricular functional MR (VFMR), which has a poor prognosis because of the relatively low ejection fraction [20], suggesting that AFMR should be considered a completely different MR etiology and disease than VFMR.

Table 4. Preoperative factors for freedom from AF after maze procedure (logistic regression analysis)

	Univariate		Multivariate	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)	*p*-value
AFMR	0.653 (0.303–1.408)	0.28		
Age (yr)	0.981 (0.953–1.010)	0.20		
Preoperative LAD on TTE	0.847 (0.639–1.124)	0.25		
Ejection fraction	0.990 (0.967–1.014)	0.42		
LVEDD	1.288 (0.864–1.745)	0.25		
Fine fibrillatory wave (< 0.5)	0.513 (0.290–0.907)	0.02*		
AF type, paroxysmal	1.656 (0.810–3.387)	0.17	0.552 (0.308–0.987)	0.05*
Sex, male	0.791 (0.456–1.373)	0.41		
LAA obliteration	0.993 (0.566–1.741)	0.98		
RHD	1.217 (0.690–2.147)	0.50		
MR	1.065 (0.602–1.881)	0.83		
CKD	0.425 (0.166–1.089)	0.08	0.527 (0.201–1.380)	0.53

CI, confidence interval; AFMR, atrial functional mitral regurgitation; LAD, left atrial dimension; TTE, transthoracic echocardiography; LVEDD, left ventricular end-diastolic diameter; AF, atrial fibrillation; LAA, left atrial appendage; RHD, rheumatic heart disease; MR, mitral regurgitation; CKD, chronic kidney disease.
*Statistically significant.

Table 5. Preoperative risk factors for junctional rhythm after maze procedure (logistic regression analysis)

	Univariate		Multivariate	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)	*p*-value
AFMR	13.857 (5.645–34.015)	< 0.001*	17.408 (4.167–72.732)	< 0.001*
Age	1.054 (1.007–1.104)	0.03*	1.088 (1.026–1.153)	0.005*
Preoperative LAD on TTE	1.727 (1.177–2.534)	0.005*	1.302 (0.770–2.201)	0.33
Ejection fraction	1.037 (1.001–1.075)	0.04*	1.061 (1.013–1.111)	0.01*
LVEDD	1.513 (0.971–2.357)	0.07	1.561 (0.770–3.168)	0.22
Fine fibrillatory wave (< 0.5 mm)	1.121 (0.518–2.425)	0.77		
AF type, Paroxysmal	0.649 (0.236–1.786)	0.40		
Sex, male	0.550 (0.252–1.199)	0.21		
LAA obliteration	1.129 (0.521–2.446)	0.76		
RHD	0.486 (0.207–1.143)	0.10	4.039 (1.061–15.367)	0.04*
MR	7.112 (2.997–16.876)	< 0.001*	2.316 (0.643–8.347)	0.12
CKD	0.517 (0.065–4.103)	0.53		

CI, confidence interval; AFMR, atrial functional mitral regurgitation; LAD, left atrial dimension; TTE, transthoracic echocardiography; LVEDD, left ventricular end-diastolic diameter; AF, atrial fibrillation; LAA, left atrial appendage; RHD, rheumatic heart disease; MR: mitral regurgitation; CKD, chronic kidney disease.
*Statistically significant.

In the sub-analysis of this study, the outcome of MV repair in AFMR was as good as that in DMR. Wagner et al. [9] published the largest study on cardiac surgery in AFMR and reported that only 5% of patients with AFMR who underwent mitral annuloplasty experienced MR recurrence, and that the reintervention rate of AFMR after MV repair was less than 2%. In this study, freedom from MR (more-than-moderate) was 87% at the latest follow-up, and only one patient (2.7%) with AFMR underwent redo-MV replacement because of MR recurrence.

This study has several limitations. First, our analysis was based on the retrospective examination of a relatively small sample of patients who underwent MR surgery using a maze procedure. Although several results showed large differences in the ratios, no significant differences were observed because of the limited number of patients. In addition, this study did not employ a randomized controlled design; therefore, it has limited statistical power. Second, long-term follow-up echo-

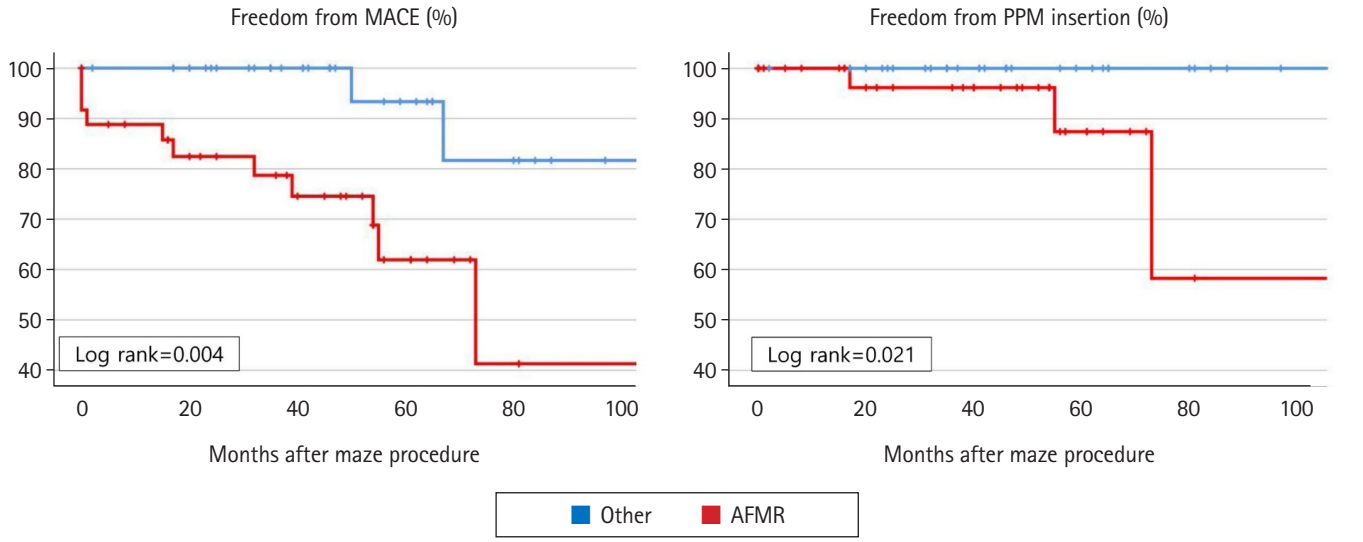

Fig. 2. Major adverse cardiac events (MACE) and ratio of permanent pacemaker insertion. PPM, permanent pacemaker; AFMR, atrial functional mitral regurgitation.

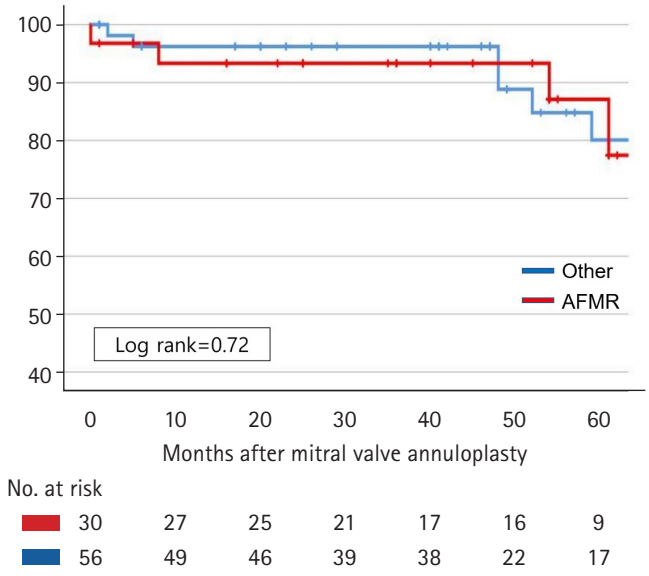

Fig. 3. Rates of mitral regurgitation (MR) recurrence after mitral annuloplasty in the atrial functional MR group compared with that in the non-atrial functional MR group. AFMR, atrial functional mitral regurgitation.

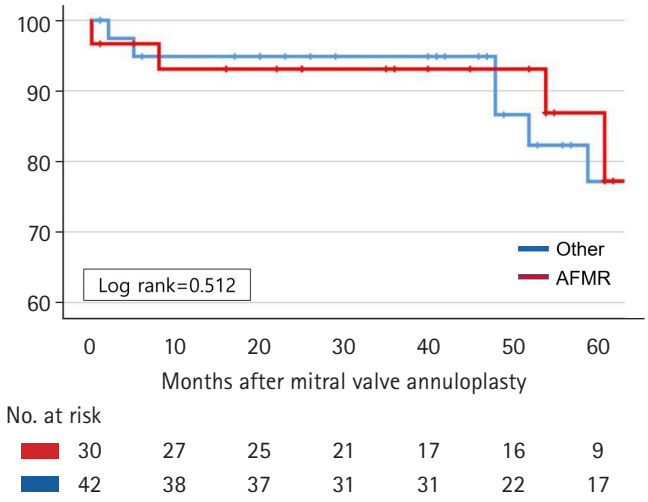

Fig. 4. Rates of mitral regurgitation (MR) recurrence after mitral annuloplasty in patients with AFMR compared with that in the degenerative MR group. AFMR, atrial functional mitral regurgitation.

cardiographic data were not available for all the patients. Therefore, our study results did not accurately reflect the long-term operative results of AFMR. Third, follow-up screening for AF recurrence was based on serial 12-lead ECG rather than 24-hour Holter monitoring. Hence, our results may have been overestimated in cases of asymptomatic paroxysmal AF.

In conclusion, the outcomes of the maze procedure in patients with AFMR were excellent and comparable to those in patients without AFMR. However, significantly more patients with AFMR required permanent pacemaker insertion postoperatively owing to sinus nodal dysfunction after the maze procedure.

Supplementary materials

Supplementary materials can be found via https://doi.org/10.46308/kmj.2024.00010.

Acknowledgements

None.

Ethics approval

The Institutional Review Board of the Dongsan Medical Center approved the study (IRB File No. 2023-04-042, April 25, 2023). The requirement for informed consent was waived due to the retrospective nature of the study.

Conflict of interest

The author has nothing to disclose.

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