Mitral valve surgery and maze procedure: the Korean experience in rheumatic versus degenerative disease

Joon Young Kim[1], Hong Rae Kim[1], Jae-Suk Yoo[1], Joon Bum Kim[1], Sung-Ho Jung[1], Jae Won Lee[2], Ho Jin Kim[1]

[1]Department of Thoracic and Cardiovascular Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea; [2]Department of Thoracic and Cardiovascular Surgery, Armed Forces Capital Hospital, Gyeonggi-do, Republic of Korea

Correspondence to: Ho Jin Kim, MD, PhD. Department of Thoracic and Cardiovascular Surgery, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Republic of Korea. Email: hjkim1978@amc.seoul.kr.

Background: In Korea, rheumatic mitral valve (MV) disease remains relatively prevalent compared with Western countries. Given this demographic profile, we aimed to evaluate long-term rhythm and clinical outcomes of surgical ablation of atrial fibrillation (AF) during MV surgery in patients with degenerative versus rheumatic MV disease, using the data from the nation's highest-volume center.

Methods: We retrospectively analyzed consecutive patients with AF who underwent MV surgery with concomitant surgical ablation between 2001 and 2020 at a high-volume center in Korea. Patients were categorized by MV etiology (rheumatic *vs.* degenerative). The primary outcome was AF recurrence after a 3-month blanking period. Secondary outcomes included all-cause mortality, stroke, and permanent pacemaker (PPM) implantation. The probability of AF recurrence was estimated using logistic regression with generalized estimating equations, and competing risk models were used to assess stroke and PPM implantation.

Results: Among 1,872 patients (mean age 58.7±11.5 years; 56.9% women), 1,157 (61.8%) had rheumatic MV disease, and 715 (38.2%) had degenerative disease. Compared with patients with degenerative disease, those with rheumatic disease were younger, more often female, had more persistent AF, larger left atrial dimensions, and a higher likelihood of undergoing MV replacement. The adjusted probability of AF recurrence at 3, 5, and 10 years was 23.6%, 28.6%, and 40.1%, respectively, and did not significantly differ between rheumatic and degenerative groups (10-year: 39.8% *vs.* 40.6%; P=0.746). Rheumatic etiology was not associated with an increased risk of death (P=0.518), stroke (P=0.520), or PPM implantation (P=0.052).

Conclusions: In a contemporary Korean cohort, surgical ablation during MV surgery provided sustained rhythm control and favorable clinical outcomes in patients with both degenerative and rheumatic disease. Given the continued burden of rheumatic heart disease in Korea, these findings support the routine application of surgical ablation during MV surgery, regardless of underlying etiology.

Keywords: Mitral valve surgery (MV surgery); atrial fibrillation (AF); surgical ablation

Submitted Aug 11, 2025. Accepted for publication Dec 17, 2025. Published online Jan 07, 2026.
doi: 10.21037/acs-2025-dmv-0157
View this article at: https://dx.doi.org/10.21037/acs-2025-dmv-0157

Introduction

The number of major cardiac surgeries performed annually in Korea is estimated to range from 10,000 to 15,000 (1). Notably, heart valve surgery has become the most common type of cardiac surgery in Korea in the last decade, in contrast to the United States, where coronary artery bypass grafting (CABG) still accounts for more than 50% of all cardiac surgeries (2). According to data from the Korean Society for Thoracic and Cardiovascular Surgery, mitral valve (MV) surgery—either isolated or combined with other

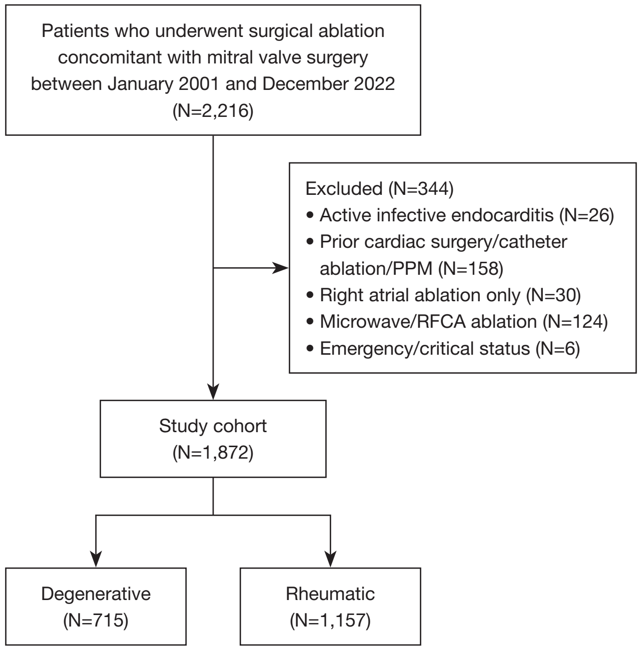

Figure 1 Flow chart of patient selection, showing the inclusion and exclusion criteria and the final study cohort. PPM, permanent pacemaker; RFCA, radiofrequency catheter ablation.

valve procedures—accounts for approximately 40% of valve surgeries (3).

Atrial fibrillation (AF) is present in approximately 30% of patients undergoing MV surgery (4,5). With an aging population and increasing prevalence of age-related comorbidities, the incidence of AF is expected to rise further (6). In our previous study using national cohort data, we reported that surgical ablation for AF, including the gold-standard Cox-Maze procedure, is performed concomitantly in 50–60% of MV surgery cases and is associated with reduced risks of all-cause mortality and thromboembolism (7).

Despite these compelling findings, national data lacked detailed clinical and operative variables. A single-center, high-volume dataset may therefore provide more granular evidence on the safety and the effectiveness of surgical ablation in real-world practice. Furthermore, although the incidence of rheumatic MV disease has markedly declined in Western countries, Korea continues to have a relatively high prevalence. Therefore, comparative analyses on the benefits of surgical ablation between rheumatic and degenerative MV disease could address this unmet clinical need. Accordingly, we evaluated contemporary clinical and rhythm outcomes in AF patients with either degenerative or rheumatic etiology undergoing MV surgery with concomitant surgical ablation at the highest-volume center in Korea.

Methods

Study cohort

From the Institutional Cardiac Surgery Database of Asan Medical Center, we identified consecutive adult patients (aged ≥18 years) with AF who underwent elective MV surgery with concomitant surgical ablation between January 2001 and December 2020. Patients were excluded if they (I) had active infective endocarditis; (II) had a history of previous cardiac surgery, surgical or catheter ablation, or permanent pacemaker (PPM) implantation; (III) underwent right atrial ablation only; (IV) received microwave or radiofrequency energy ablation; or (V) were in emergency or critical status, such as requiring intubation or extracorporeal membrane oxygenation (*Figure 1*).

This study was approved by the Institutional Review Board of Asan Medical Center (IRB No. 2025-0706; approval date: June 23, 2025). Informed consent was waived due to the retrospective nature of the study.

Surgical techniques

MV surgery was performed via either a median full-sternotomy (n=1,184) or right mini-thoracotomy (RMT) (n=688), depending on the feasibility of peripheral cannulation and the need for concomitant procedures such as aortic valve surgery or CABG. The minimally invasive RMT approach utilized robotic systems, including the Automated Endoscopic System for Optimal Positioning (AESOP, Computer Motion, Inc.) between 2004 and 2020, the SOLOASSIST (AKTORmed GmbH) since 2020, or the Da Vinci System (Intuitive Surgical) since 2007 (8). MV repair was primarily performed in patients with degenerative etiology and selectively applied in those with rheumatic etiology when mitral insufficiency was the predominant pathology (9,10). MV replacement was the preferred strategy in patients with rheumatic etiology presenting with mitral stenosis or steno-insufficiency, and in those with degenerative etiology when repair was deemed infeasible.

Surgical ablation was primarily performed using a cryoprobe—either the Cardioblate CryoFlex (Medtronic Inc., Minneapolis, MN, USA) or cryoICE (AtriCure Inc., Mason, OH, USA)—with a Cox-Maze III lesion set or its modification to the right atrium (RA). Left atrial (LA) ablation incorporated a box lesion encircling the pulmonary veins (PVs), connecting lines to the posterior mitral annulus and the left atrial appendage (LAA), and an epicardial coronary sinus lesion. RA ablation was selectively performed in patients with enlarged RA, significant tricuspid regurgitation (TR), or high risk for AF recurrence (11). In patients with markedly enlarged LA, the free wall between the right inferior PV and the posterior MV annulus was resected to reduce LA size (12). The LAA was closed by resection with a stapler or sutures, by endocardial obliteration (primarily in the RMT approach), or by occlusion with a clip device (13,14).

Postoperative anticoagulation and rhythm management

For MV replacement, the choice between a mechanical or bioprosthetic valve was made by the patient or family after consultation with the operating surgeon, taking into consideration age, comorbidities, the estimated risk of MV reintervention, and preferences regarding long-term warfarin use (15). Mechanical valve recipients received lifelong warfarin therapy targeting an international normalized ratio (INR) of 2.0–3.0. For those undergoing bioprosthetic MV replacement or MV repair with an annuloplasty ring, warfarin (INR 2.0–3.0) or direct oral anticoagulants (DOACs) were administered for 3 to 6 months. The continuation of anticoagulation thereafter was individualized based on sinus rhythm restoration and the estimated risk of thromboembolism.

Sinus rhythm restoration was evaluated using 24-hour Holter monitoring prior to hospital discharge. Follow-up rhythm assessments were conducted during outpatient visits using 24-hour Holter monitoring or electrocardiography (ECG) after a 3-month blanking period and subsequently at 6- to 12-month intervals. Recurrence of AF was defined as any documented episode of AF, atrial flutter, or atrial tachycardia lasting ≥30 seconds after the blanking period (16,17). PPM implantation was considered for patients with persistent symptomatic bradyarrhythmia, sinus node dysfunction, or high-degree atrioventricular block, as determined by cardiac electrophysiologists.

Outcomes of interest and clinical follow-up

The primary outcome was AF recurrence after a 3-month blanking period. The secondary outcomes included all-cause mortality and adverse clinical events (stroke, PPM implantation, and catheter ablation). Early postoperative mortality and complications occurring within 30 days of MV surgery or during the index hospitalization were also evaluated.

Clinical follow-up and rhythm data were collected between May and June 2025. Patients who were alive and had not experienced adverse events were censored at the time of data acquisition. Mortality data were validated through institutional electronic records linked to the Korean National Health Insurance Service, which covers approximately 98% of the Korean population (7).

Statistical analysis

Categorical variables, presented as frequencies and percentages, were compared using the χ^2 test or Fisher's exact test, as appropriate. Continuous variables, presented as mean ± standard deviation (SD) for normally distributed data or median with interquartile range (IQR) for skewed data, were analyzed using Student's *t*-test or the Mann-Whitney *U* test.

To evaluate rhythm outcomes, a logistic regression model with generalized estimating equations (GEE) for a binary sequence of AF was used to estimate the probability of AF recurrence at predefined time points (6 months, 1, 3, 5, and 10 years), accounting for within-subject correlation. For patients who underwent catheter ablation or PPM implantation postoperatively, only rhythm data prior to those events were included.

The association between degenerative *vs.* rheumatic etiology and early and long-term clinical outcomes was evaluated using multivariable analysis. Clinically relevant variables and operative characteristics in *Tables 1,2* were first assessed in univariable models, and covariates with a P value ≤0.05 were selected for inclusion in the multivariable models. A stepwise backward elimination method was then applied to retain only covariates with a P value ≤0.05 in the final model. For the analysis of all-cause mortality, a Cox proportional-hazard model was used to estimate hazard ratios, and the proportional hazards assumption was tested using Schoenfeld residuals. To identify predictors of stroke and PPM implantation while accounting for the competing risk of death, Fine-Gray subdistribution hazard models were employed.

All statistical analyses were performed using R software (version 4.5.1, R Foundation for Statistical Computing). All P values were two-tailed, and P values <0.05 were considered statistically significant.

Table 1 Baseline characteristics between patients with degenerative and rheumatic mitral valve disease

Variables	Total (N=1,872)	Mitral etiology		P value
		Degenerative (N=715)	Rheumatic (N=1,157)	
Age (years)	58.7±11.5	61.3±11.8	57.1±11.0	<0.001
Female	1,065 (56.9)	275 (38.5)	790 (68.3)	<0.001
BMI (kg/m^2)	23.4±3.3	24.0±3.6	23.0±3.1	<0.001
AF type				<0.001
Paroxysmal	246 (13.1)	134 (18.7)	112 (9.7)	
Persistent (≤1 year)	609 (32.5)	219 (30.6)	390 (33.7)	
Longstanding persistent (>1 year)	1,017 (54.3)	362 (50.6)	655 (56.6)	
Valve pathology				<0.001
Stenosis	500 (26.7)	29 (4.1)	471 (40.7)	
Insufficiency	937 (50.1)	662 (92.6)	275 (23.8)	
Steno-insufficiency	435 (23.2)	24 (3.4)	411 (35.5)	
Comorbidities				
Hypertension	646 (34.5)	348 (48.7)	298 (25.8)	<0.001
Diabetes mellitus	275 (14.7)	103 (14.4)	172 (14.9)	0.837
Dyslipidemia	525 (28.0)	162 (22.7)	363 (31.4)	<0.001
Congestive heart failure	177 (9.5)	92 (12.9)	85 (7.3)	<0.001
Chronic lung disease	159 (8.5)	61 (8.5)	98 (8.5)	>0.99
History of stroke	248 (13.2)	58 (8.1)	190 (16.4)	<0.001
Coronary artery disease	206 (11.0)	115 (16.1)	91 (7.9)	<0.001
Previous PCI	46 (2.5)	25 (3.5)	21 (1.8)	0.033
Peripheral arterial disease	139 (7.4)	90 (7.8)	49 (6.9)	0.515
eGFR (mL/min/1.73 m^2)				<0.001
<30	28 (1.5)	20 (2.8)	8 (0.7)	
30 to <60	311 (16.6)	146 (20.4)	165 (14.3)	
≥60	1,533 (81.9)	549 (76.8)	984 (85.0)	
CHA_2DS_2-VASc Score	1.9±1.5	1.9±1.5	1.9±1.5	0.329
Low risk	680 (36.3)	180 (25.2)	500 (43.2)	
Intermediate risk	486 (26.0)	223 (31.2)	263 (22.7)	
High risk	706 (37.7)	312 (43.6)	394 (34.1)	
Hemoglobin (g/dL)	13.2±1.9	13.3±2.0	13.1±1.8	0.139
NYHA class 3 or 4	409 (21.8)	175 (24.5)	234 (20.2)	0.035

Table 1 (*continued*)

Table 1 (*continued*)

Variables	Total (N=1,872)	Mitral etiology		P value
		Degenerative (N=715)	Rheumatic (N=1,157)	
Echocardiographic data				
LV ejection fraction (%)	56.5±9.3	59.6±9.9	55.2±8.7	<0.001
LVEDD (mm)	55.1±8.9	59.0±9.2	52.7±7.9	<0.001
LVESD (mm)	37.2±7.8	39.0±8.6	36.1±7.1	<0.001
LA diameter (mm)	57.9±9.8	57.0±10.6	58.5±9.3	0.002
TR ≥ moderate	813 (43.4)	291 (40.7)	522 (45.1)	0.068
sPAP (mmHg)	47.7±13.9	47.5±14.7	47.8±13.4	0.660

Values are presented as n (%) or mean ± standard deviation. CHA_2DS_2-VASc risk categories: low risk, 0 (male) or 1 (female) points; intermediate risk, 1 (male) or 2 (female) points; high risk, ≥2 (male) or ≥3 (female) points. AF, atrial fibrillation; BMI, body mass index; eGFR, estimated glomerular filtration rate; LA, left atrial; LV, left ventricular; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; sPAP, systolic pulmonary artery pressure; TR, tricuspid regurgitation.

Table 2 Operative profiles between patients with degenerative and rheumatic mitral valve disease

Variables	Total (N=1,872)	Mitral etiology		P value
		Degenerative (N=715)	Rheumatic (N=1,157)	
Mitral valve procedure				<0.001
Repair	692 (37.0)	577 (80.7)	115 (9.9)	
Replacement	1,190 (63.6)	143 (20.0)	1,047 (90.5)	
Use of mechanical valve	980 (52.4)	108 (75.5)	872 (83.3)	0.022
Minimally invasive approach	688 (36.8)	340 (47.6)	348 (30.1)	<0.001
Concomitant procedure				
AV surgery	412 (22.0)	70 (9.8)	342 (29.6)	<0.001
TV surgery	1,030 (55.0)	355 (49.7)	675 (58.3)	<0.001
CABG	90 (4.8)	48 (6.7)	42 (3.6)	0.004
Others	58 (3.1)	29 (4.1)	29 (2.5)	0.081
Ablation lesion sets				0.014
BA ablation	1151 (61.5)	414 (57.9)	737 (63.7)	
LA ablation	721 (38.5)	301 (42.1)	420 (36.3)	
LA size reduction	1,020 (54.5)	357 (49.9)	663 (57.3)	0.002
CPB time (min)	164.9±54.6	172.0±56.8	160.4±52.8	<0.001
ACC time (min)	110.9±37.2	110.9±35.7	110.9±38.0	0.988
Year of surgery				<0.001
2001–2005	165 (8.8)	39 (5.5)	126 (10.9)	
2006–2010	438 (23.4)	154 (21.6)	284 (24.6)	
2011–2015	511 (27.3)	201 (28.2)	310 (26.9)	
2016–2020	758 (40.5)	321 (45.0)	437 (37.9)	

Values are presented as n (%) or mean ± standard deviation. ACC, aortic cross-clamping; AV, aortic valve; BA, biatrial; CABG, coronary artery bypass surgery; CPB, cardiopulmonary bypass; LA, left atrial; TV, tricuspid valve.

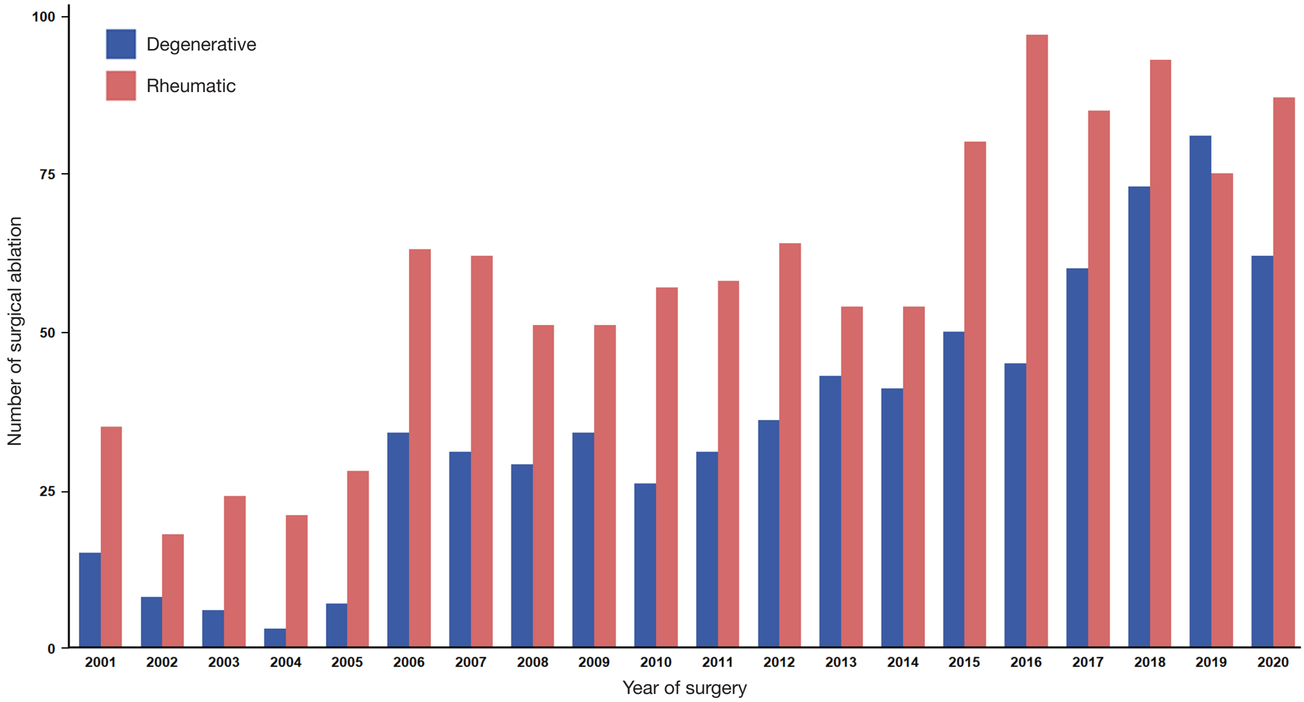

Figure 2 Annual trends in MV surgery with concomitant surgical ablation by etiology. MV, mitral valve.

Results

Baseline and operative characteristics

Among 2,216 patients with AF who underwent MV surgery and concomitant surgical ablation, 344 were excluded, and 1,872 patients (mean age 58.7±11.5 years; 1,065 women) were included in the analysis (*Figure 1*). Degenerative MV disease was present in 715 patients (38.2%) and rheumatic MV disease in 1,157 patients (61.8%) (*Figure 2*).

Baseline characteristics of patients with degenerative versus rheumatic etiologies are summarized in *Table 1*. Compared with those with rheumatic disease, patients with degenerative MV disease were older and more commonly male. The prevalence of paroxysmal AF (18.7% *vs.* 9.7%; P<0.001), mitral insufficiency (92.6% *vs.* 23.8%; P<0.001), and coronary artery disease was significantly higher in those with degenerative MV disease. In contrast, patients with rheumatic MV disease had larger LA dimensions (P=0.002), more significant TR (45.1% *vs.* 40.7%; P=0.068), and were more likely to have a history of stroke.

Operative profiles are detailed in *Table 2*. MV repair was more frequently performed in patients with degenerative disease than in those with rheumatic disease (80.7% *vs.* 9.9%; P<0.001). Among patients undergoing MV replacement, the use of mechanical prostheses was more frequent in the rheumatic group than in the degenerative group (75.5% *vs.* 83.3%; P=0.022). Tricuspid valve (TV) surgery was performed concomitantly in 1,030 patients (55.0%).

Clinical and rhythm outcomes

Early mortality occurred in 24 patients (3.4%) with degenerative disease and in 22 patients (1.9%) with rheumatic disease (P=0.370). The adjusted risks of other early complications were comparable between the groups, except for new-onset dialysis (P=0.009) (*Table 3*).

During follow-up, the probability of AF recurrence at 3, 5, and 10 years after surgical ablation was 23.6%, 28.6%, and 40.1%, respectively (*Figure 3*). Over a median follow-up of 9.6 years (IQR, 6.6–14.6 years), totaling 19,972 patient-years of observation, death, stroke, and PPM implantation occurred in 254 [1.27% per patient-year], 114 (0.57%/PY), and 170 (0.85%/PY) patients, respectively. The cumulative incidence of stroke at 5, 10, and 15 years postoperatively was 3.4%, 9.0%, and 11.3%, respectively, while the corresponding incidence of PPM implantation was 7.3%, 10.4%, and 15.7% (*Figure 4*).

Table 3 Clinical outcomes between patients with degenerative and rheumatic mitral valve disease

Outcomes	Mitral etiology		OR or HR/sHR (95% CI)	P value
	Degenerative (N=715)	Rheumatic (N=1,157)		
Early outcomes, n (%)				
Early death	24 (3.4)	22 (1.9)	0.75 (0.40–1.41)	0.370
Bleeding requiring exploration	45 (6.3)	62 (5.4)	1.00 (0.65–1.53)	0.989
LCOS requiring MCS	20 (2.8)	24 (2.1)	0.89 (0.47–1.69)	0.710
Stroke	22 (3.1)	33 (2.9)	1.06 (0.59–1.94)	0.838
New-onset dialysis	31 (4.3)	38 (3.3)	0.47 (0.27–0.84)	0.009
Surgical wound infection	7 (1.0)	6 (0.5)	0.58 (0.18–1.83)	0.349
Early PPM implantation	23 (3.2)	45 (3.9)	1.26 (0.75–2.16)	0.391
Early AF recurrence (≤ 3 months)	405 (56.6)	671 (58.0)	1.04 (0.84–1.28)	0.704
Overall outcomes, n (%/PY)				
All-cause death	118 (1.7)	136 (1.0)	0.91 (0.70–1.20)	0.518
Stroke	38 (0.6)	76 (0.6)	1.15 (0.76–1.74)	0.520
PPM implantation	54 (0.8)	116 (0.9)	1.39 (1.00–1.95)	0.052
Atrioventricular block	11 (0.2)	21 (0.2)	–	–
Sinus node dysfunction	43 (0.6)	95 (0.7)	–	–
Catheter ablation	6 (0.1)	8 (0.1)	1.13 (0.38–3.39)	0.830

Early outcomes are presented as odds ratios; overall outcomes are presented as hazard or sub-distributional hazard ratios. AF, atrial fibrillation; CI, confidence interval; HR, hazard ratio; LCOS, low cardiac output syndrome; MCS, mechanical circulatory support; OR, odds ratio; PPM, permanent pacemaker; PY, patient-year; sHR, sub-distributional hazard ratio.

Impact of mitral etiologies: degenerative *vs.* rheumatic

Table 4 summarizes the candidate variables identified in univariable analysis and the final multivariable model for AF recurrence after a 3-month blanking period. Advanced age, larger LA diameter, significant TR, persistent AF (*vs.* paroxysmal AF), and documented AF within 3 months of surgical ablation emerged as significant predictors of AF recurrence. However, rheumatic etiology, compared with degenerative MV disease, was not associated with an increased risk of AF recurrence (P=0.678). The probability of AF recurrence in the degenerative group at 3, 5, and 10 years postoperatively was 23.9%, 29.0%, and 40.6%, respectively, while the corresponding probabilities in the rheumatic group were 23.4%, 28.4% and 39.8% (*Figure 3B*).

The results of univariable and multivariable analyses for predicting the risk of death, stroke, and PPM implantation are summarized in Tables S1-S3, respectively. Rheumatic etiology was not significantly associated with the risk of death (P=0.518), stroke (P=0.520), or PPM implantation (P=0.052) (*Table 3* and *Figure 5*).

Discussion

In this contemporary cohort of patients who underwent MV surgery with concomitant surgical ablation at a high-volume center in Korea, we evaluated long-term clinical and rhythm outcomes and examined the impact of rheumatic versus degenerative MV etiology. Our institution performs approximately 1,000–1,500 adult cardiac surgeries, annually, representing about 10–15% of the total national cardiac surgery volume of 10,000–15,000 cases. This substantial share ensures that the data are highly representative of the Korean cardiac surgery landscape. Our study findings revealed significant differences in demographic, clinical, and rhythm characteristics between patients with degenerative and rheumatic MV disease. These differences also

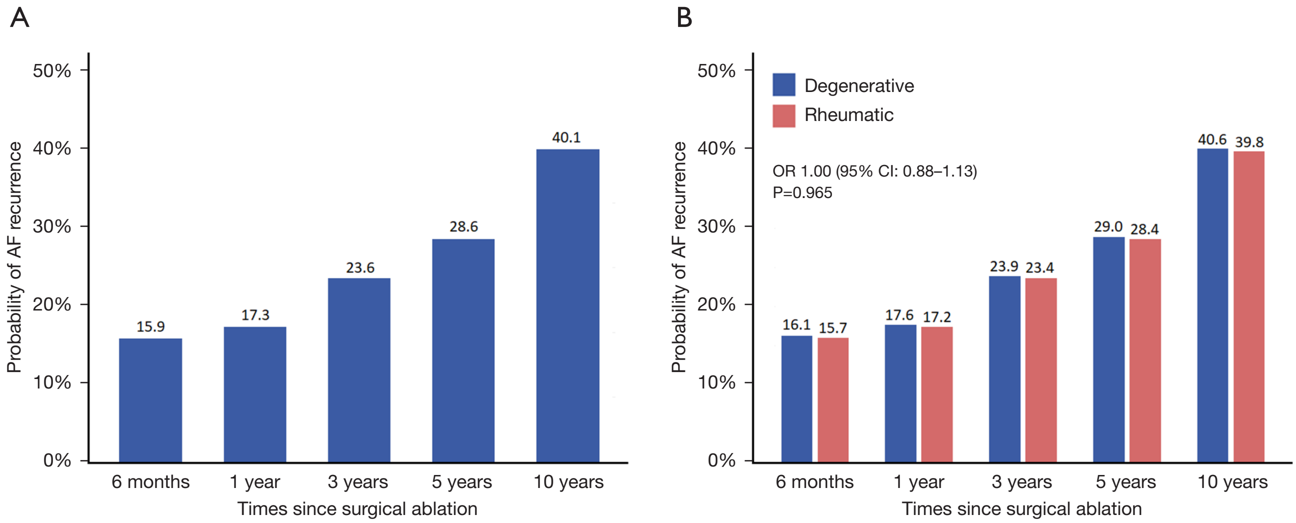

Figure 3 Probability of AF recurrence at 0.5, 1, 3, 5 and 10 years after surgical ablation (A) in the entire cohort and (B) by etiology (degenerative *vs.* rheumatic). AF, atrial fibrillation; CI, confidence interval; MV, mitral valve; OR, odds ratio.

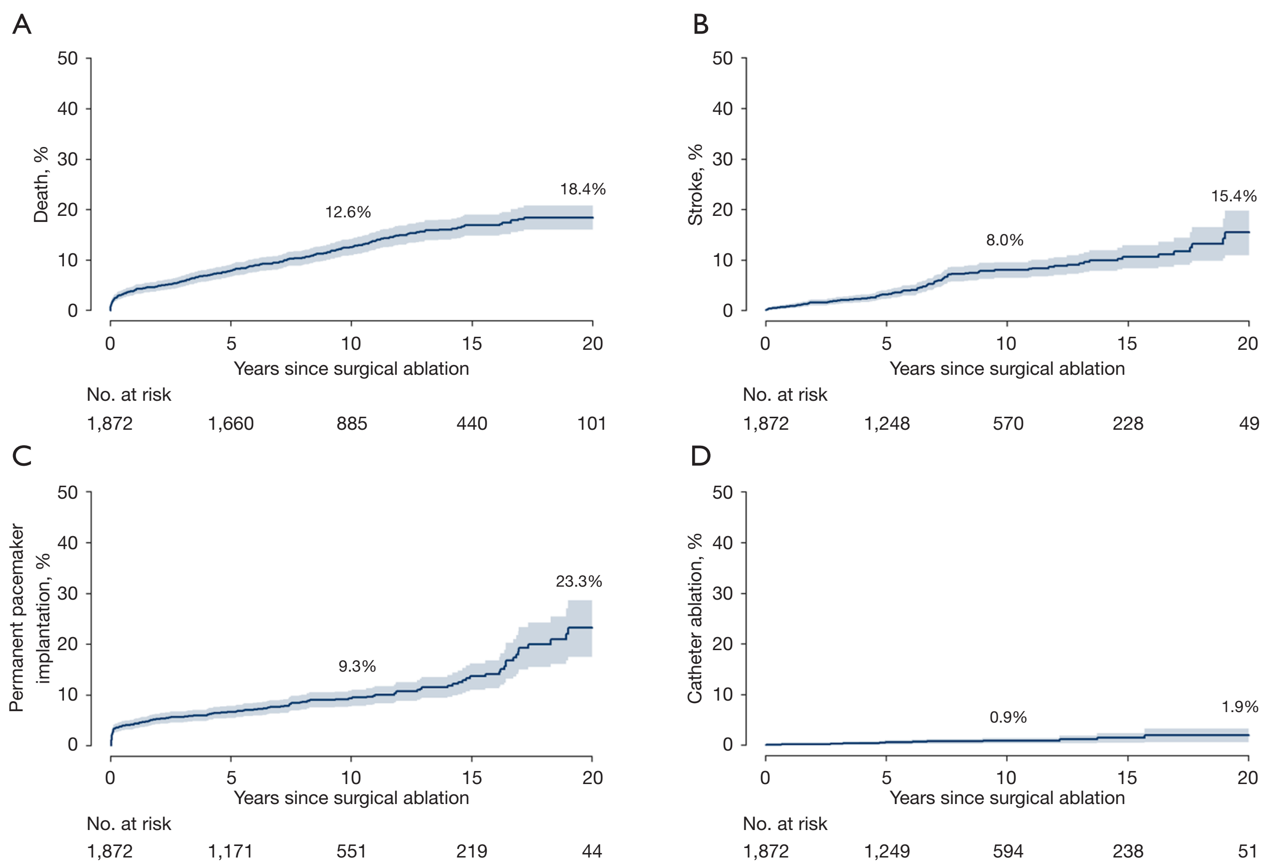

Figure 4 Time-to-event curves for (A) death, (B) stroke, (C) permanent pacemaker implantation, and (D) catheter ablation after MV surgery with concomitant surgical ablation. MV, mitral valve.

Table 4 Univariable and multivariable models for atrial fibrillation recurrence

Variables	AF recurrence					
	Univariable			Multivariable		
	OR	95% CI	P	OR	95% CI	P
Rheumatic	1.00	0.88–1.13	0.965	0.97	0.84–1.12	0.678
Age (by 1-year increment)	1.05	1.05–1.06	<0.001	1.04	1.04–1.05	<0.001
Persistent AF	2.58	2.06–3.24	<0.001	1.34	1.05–1.71	0.017
Hypertension	1.28	1.13–1.45	<0.001	–	–	–
Diabetes mellitus	1.51	1.29–1.77	<0.001	–	–	–
Congestive heart failure	1.35	1.12–1.63	0.002	–	–	–
Coronary artery disease	1.51	1.26–1.80	<0.001	–	–	–
NYHA class 3 or 4	1.22	1.06–1.41	0.005	–	–	–
LV ejection fraction (%)	1.01	1.00–1.01	0.036	–	–	–
LA diameter (by 1-mm increment)	1.06	1.06–1.07	<0.001	1.05	1.05–1.06	<0.001
TR ≥ moderate	2.49	2.20–2.81	<0.001	1.51	1.32–1.74	<0.001
Minimally invasive approach	0.47	0.41–0.54	<0.001	0.74	0.63–0.86	<0.001
LA ablation only	0.69	0.60–0.78	<0.001	–	–	–
LA size reduction	1.66	1.47–1.87	<0.001	–	–	–
Early AF recurrence	5.03	4.32–5.86	<0.001	3.39	2.88–3.98	<0.001
Time, year						
0.5	Ref			Ref		
1	1.09	0.90–1.32	0.400	1.11	0.90–1.37	0.329
3	1.48	1.23–1.78	<0.001	1.64	1.34–2.00	<0.001
5	1.78	1.47–2.15	<0.001	2.13	1.73–2.62	<0.001
10	2.70	2.24–3.26	<0.001	3.55	2.87–4.39	<0.001

Candidate variables were initially screened with univariable analyses. Significant variables with a P<0.05 in univariable models were used to build a full multivariable model. The full multivariable model was built with all variables screened from univariable analyses (MV etiology, age, sex, AF type, hypertension, diabetes mellitus, dyslipidemia, congestive heart failure, chronic lung disease, history of stroke, coronary artery disease, eGFR, hemoglobin, peripheral arterial disease, NYHA class 3 or 4, LV ejection fraction, LVEDD, LVESD, LA diameter, significant TR, LA ablation, LA size reduction, CPB time, ACC time, rhythm follow up time and early AF recurrence). Only variables with a P<0.05 in the full multivariable model were retained in the final multivariable model. ACC, aortic cross-clamping; AF, atrial fibrillation; CI, confidence interval; CPB, cardiopulmonary bypass; eGFR, estimated glomerular filtration rate; LA, left atrial; LV, left ventricular; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; MV, mitral valve; NYHA, New York Heart Association; OR, odds ratio; TR, tricuspid regurgitation.

translated into variations in surgical strategies, including the type of MV procedure (repair *vs.* replacement) and the profile of concomitant procedures. Despite the notion of reduced efficacy of surgical ablation in rheumatic disease, the adjusted 10-year probability of AF recurrence was comparable between the two groups—39.8% in the rheumatic group and 40.6% in the degenerative group (P=0.746)—indicating sustained rhythm control in the majority of patients in both groups.

Surgical ablation for AF is known to decrease the risk of stroke and mortality and to improve quality of life by restoring sinus rhythm. Our previous studies have

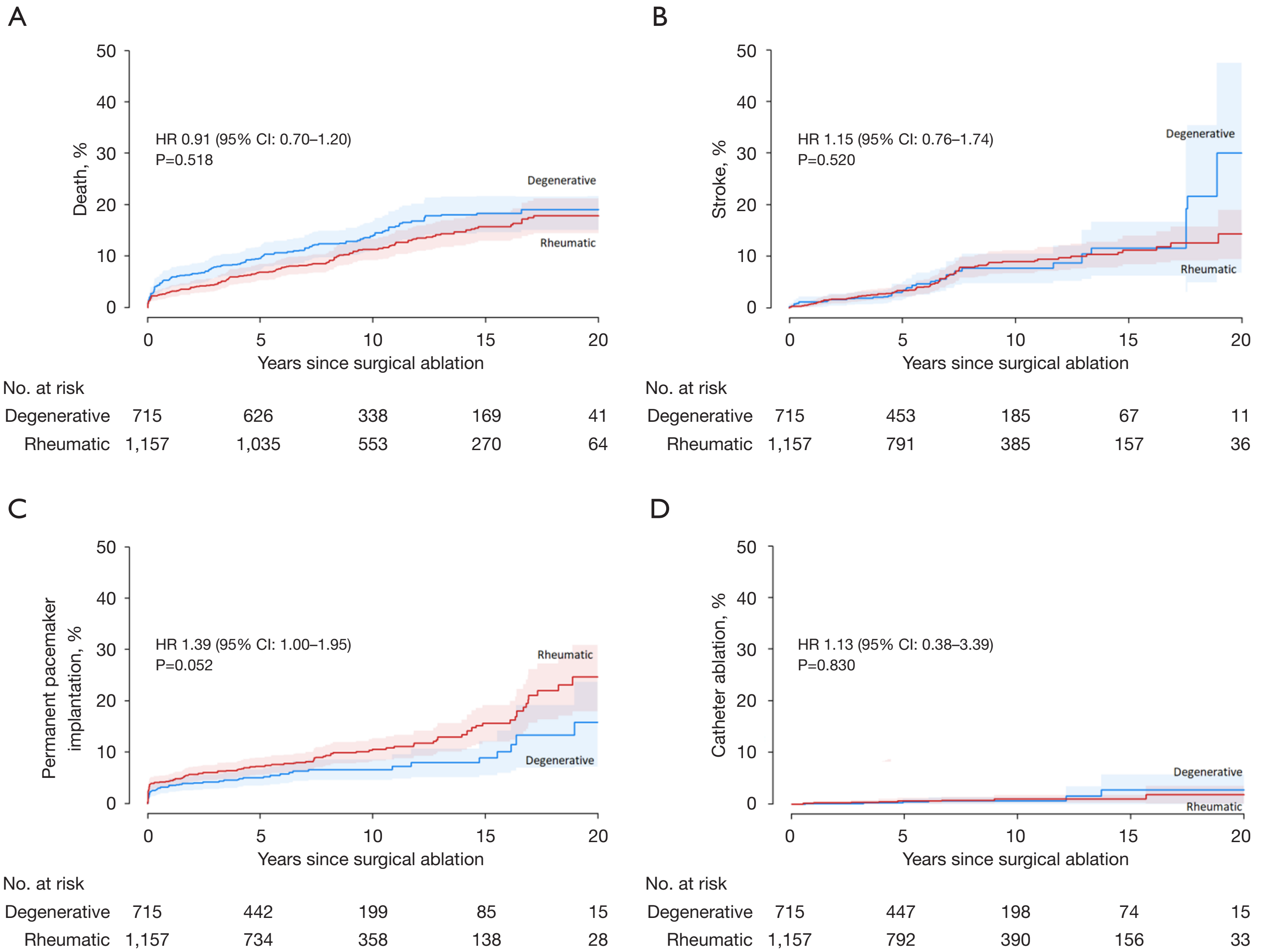

Figure 5 Time-to-event curves by etiology (degenerative *vs.* rheumatic) for (A) death, (B) stroke, (C) permanent pacemaker implantation, and (D) catheter ablation after MV surgery with concomitant surgical ablation. CI, confidence interval; HR, hazard ratio; MV, mitral valve.

demonstrated these benefits even in patients receiving mechanical prostheses, who require lifelong anticoagulation with warfarin (18), as well as in high-risk patients, such as elderly patients, those with reduced left ventricular function, or patients with markedly enlarged LA (19-21). Accordingly, the Korean guidelines for AF surgery recommend concomitant surgical ablation at the time of MV surgery as a Class I indication, consistent with international guidelines (4,22).

Despite these strong multi-society recommendations, surgical ablation during cardiac surgery remains underutilized in Korea. Large-scale observational studies report that the rate of surgical ablation during cardiac surgery is approximately 50% to 60% in Korea (7,23). This trend aligns with findings from the United States, as reported in the Society of Thoracic Surgeons (STS) database (24). Although surgical ablation is currently performed in nearly all patients with AF undergoing cardiac surgery at our institution, the historical rate of surgical ablation during rheumatic MV surgery was 66.1% (n=812) between 1997 and 2016 (25).

Although the global burden of rheumatic heart disease has declined, particularly in Western countries, it remains relatively prevalent in Korea, accounting for over 60% of MV surgeries in our cohort. Rheumatic fever tends to affect younger individuals and often leads to MV stenosis. Accordingly, surgical profiles for rheumatic MV disease, compared with degenerative etiology, present distinct features, including a higher likelihood of MV replacement using mechanical prosthesis (9).

Our study demonstrated that patients with rheumatic etiology exhibited predominant mitral stenosis or mixed steno-insufficiency, a higher prevalence of persistent AF, larger LA dimensions, and more significant TR. Rheumatic pathology is characterized by chronic inflammatory involvement of the myocardium, leading to adverse remodeling and fibrosis of the LA wall. Prior studies have suggested that such structural alterations may impair the efficacy of surgical ablation (26). However, contrary to these concerns, our study found no significant difference in long-term AF recurrence between patients with rheumatic and degenerative etiologies. This aligns with the findings of Labin *et al.*, who reported comparable rhythm outcomes after the Cox-Maze IV procedure in both rheumatic and degenerative populations (27). These findings suggest that surgical ablation should be performed during MV surgery regardless of the underlying etiology.

Since the introduction of surgical AF ablation in the 1980s, various lesion sets have been described; however, the Maze procedure designed by Dr. James Cox remains the gold standard. At our institution, cryoablation with a Cox-Maze III lesion set or a modified version focused on the RA has been the primary strategy. Biatrial (BA) ablation was routinely applied in the early 2000s. Since the mid-2000s, however, we have tailored the extent of ablation based on patient characteristics, adding RA ablation in the presence of right atrial pathology (e.g., dilated RA, significant TR, prolonged AF duration) (28,29). Our previous study showed the risks of AF recurrence and adverse clinical events were comparable between patients undergoing LA-only versus BA ablation after adjustments for measurable confounders, indicating that LA ablation can be as safe and efficacious as BA ablation in carefully selected patients (11,30).

A minimally invasive RMT approach has been adopted for MV surgery at our institution since 2002, further enhanced by the introduction of robotic systems in 2004. More recently, MV repair using a three-dimensional endoscopic system via the RMT approach has become our preferred approach (31). Accordingly, the RMT approach combined with cryoablation has also seen increased utilization. Our previous study reported that robotic-assisted surgical ablation during MV repair using the da Vinci system yielded favorable rhythm outcomes, with a 5-year freedom from AF rate of 93.3% (32). A more recent study also showed comparable freedom from AF between the RMT and conventional sternotomy approaches (33). However, this study also suggested that the effect of surgical ablation may differ in certain high-risk subgroups, favoring sternotomy approach and underscoring the importance of appropriate patient selection.

This study has several limitations inherent to its retrospective and observational design. Selection bias in both surgical and ablation strategies cannot be entirely excluded, particularly concerning the choice of lesion sets and surgical approaches. Additionally, as the study was conducted at a high-volume center with extensive experience in surgical ablation, the generalizability of the findings may be limited and should be interpreted with caution.

Conclusions

In this contemporary Korean cohort from a high-volume center, where rheumatic MV disease remains prevalent, tailored cryoablation strategies based on the Cox-Maze III lesion set achieved favorable long-term rhythm outcomes. Surgical ablation of AF was safely and effectively performed in patients with either degenerative or rheumatic MV disease, despite distinct clinical and operative characteristics. These findings support the routine use of surgical ablation during MV surgery, regardless of underlying etiology.

Acknowledgments

None.

Footnote

Funding: None.

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study protocol was approved by the Institutional Review Board of Asan Medical Center (Study No.: 2025-0706, Date of approval: 2025-06-23).

References

1. Park SJ, Kim DJ, Kim JB, et al. Cardiothoracic surgery training in South Korea: Challenges and new hopes. J Thorac Cardiovasc Surg 2020;159:205-214.e1.
2. Iribarne A, Zwischenberger B, Hunter Mehaffey J, et al. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2024 Update on National Trends and Outcomes. Ann Thorac Surg 2025;119:1139-50.
3. Kim HJ, Kim JB, Kim SO, et al. A Risk Prediction Model for Operative Mortality after Heart Valve Surgery in a Korean Cohort. J Chest Surg 2021;54:88-98.
4. Badhwar V, Rankin JS, Damiano RJ Jr, et al. The Society of Thoracic Surgeons 2017 Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation. Ann Thorac Surg 2017;103:329-41.
5. McCarthy PM, Davidson CJ, Kruse J, et al. Prevalence of atrial fibrillation before cardiac surgery and factors associated with concomitant ablation. J Thorac Cardiovasc Surg 2020;159:2245-2253.e15.
6. Lee SR, Kim D, Kim YG, et al. Nationwide Epidemiology and Management Time Trends for Atrial Fibrillation: Insights From the Korean AF Factsheet. JACC Asia 2025;5:947-62.
7. Kim HJ, Kim YJ, Kim M, et al. Surgical ablation for atrial fibrillation during aortic and mitral valve surgery: A nationwide population-based cohort study. J Thorac Cardiovasc Surg 2024;167:981-93.
8. Kim HJ, Kim JB, Jung SH, et al. Clinical outcomes of robotic mitral valve repair: a single-center experience in Korea. Ann Cardiothorac Surg 2017;6:9-16.
9. Kim WK, Kim HJ, Kim JB, et al. Clinical outcomes in 1731 patients undergoing mitral valve surgery for rheumatic valve disease. Heart 2018;104:841-8.
10. Kwon Y, Kim HJ, Kim JB, et al. Mitral valve repair with leaflet resection versus preservation for degenerative posterior leaflet prolapse. J Thorac Cardiovasc Surg 2025;169:1704-1713.e5.
11. Kim HJ, Kim JB, Kim SO, et al. Long-Term Outcomes of Surgical Ablation for Atrial Fibrillation: Impact of Ablation Lesion Sets. JACC Asia 2021;1:203-14.
12. Choi W, Kim HJ, Park SY, et al. The Impact of Left Atrial Reduction During Surgical Ablation of Atrial Fibrillation. Semin Thorac Cardiovasc Surg 2022;34:537-46.
13. Kim HJ, Chang DH, Kim SO, et al. Left atrial appendage preservation versus closure during surgical ablation of atrial fibrillation. Heart 2022;108:1864-72.
14. Lee CH, Kim JB, Jung SH, et al. Left atrial appendage resection versus preservation during the surgical ablation of atrial fibrillation. Ann Thorac Surg 2014;97:124-32.
15. Park SJ, Ok YJ, Kim HJ, et al. Evaluating Reference Ages for Selecting Prosthesis Types for Heart Valve Replacement in Korea. JAMA Netw Open 2023;6:e2314671.
16. Joglar JA, Chung MK, Armbruster AL, et al. 2023 ACC/AHA/ACCP/HRS Guideline for the Diagnosis and Management of Atrial Fibrillation: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2024;149:e1-e156.
17. Van Gelder IC, Rienstra M, Bunting KV, et al. 2024 ESC Guidelines for the management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J 2024;45:3314-414.
18. Bum Kim J, Suk Moon J, Yun SC, et al. Long-term outcomes of mechanical valve replacement in patients with atrial fibrillation: impact of the maze procedure. Circulation 2012;125:2071-80.
19. Kim HJ, Kim JB, Jung SH, et al. Surgical ablation of atrial fibrillation in patients with a giant left atrium undergoing mitral valve surgery. Heart 2016;102:1206-14.
20. Kim JB, Chong BK, Jung SH, et al. Maze procedure in patients with left ventricular dysfunction. Int J Cardiol 2014;170:331-7.
21. Kim HJ, Kim JB, Jung SH, et al. Valve replacement surgery for older individuals with preoperative atrial fibrillation: the effect of prosthetic valve choice and surgical ablation. J Thorac Cardiovasc Surg 2014;147:1907-17.
22. Je HG, Choi JW, Hwang HY, et al. 2023 KASNet Guidelines on Atrial Fibrillation Surgery. J Chest Surg 2024;57:1-24.
23. Choi JW, Kim JB, Jung YJ, et al. Trends in Heart Valve Surgery in Korea: A Report from the Heart Valve Surgery Registry Database. J Chest Surg 2022;55:388-96.
24. Badhwar V, Rankin JS, Ad N, et al. Surgical Ablation of Atrial Fibrillation in the United States: Trends and Propensity Matched Outcomes. Ann Thorac Surg 2017;104:493-500.
25. Kim WK, Kim HJ, Kim JB, et al. Concomitant ablation of atrial fibrillation in rheumatic mitral valve surgery. J Thorac Cardiovasc Surg 2019;157:1519-1528.e5.
26. Wang H, Han J, Wang Z, et al. A prospective randomized trial of the cut-and-sew Maze procedure in patients undergoing surgery for rheumatic mitral valve disease. J

Thorac Cardiovasc Surg 2018;155:608-17.
27. Labin JE, Haque N, Sinn LA, et al. The Cox-Maze IV procedure for atrial fibrillation is equally efficacious in patients with rheumatic and degenerative mitral valve disease. J Thorac Cardiovasc Surg 2017;154:835-44.
28. McCarthy PM. The maze IV operation is not always the best choice: Matching the procedure to the patient. JTCVS Tech 2023;17:79-83.
29. McCarthy PM, Cox JL. Practical approaches to concomitant surgical ablation of atrial fibrillation: Matching the ablation to the patient. J Thorac Cardiovasc Surg 2025;169:907-15.
30. Kim JB, Bang JH, Jung SH, et al. Left atrial ablation versus biatrial ablation in the surgical treatment of atrial fibrillation. Ann Thorac Surg 2011;92:1397-404; discussion 1404-5.
31. Kim J, Yoo JS. Totally endoscopic mitral valve repair using a three-dimensional endoscope system: initial clinical experience in Korea. J Thorac Dis 2020;12:705-11.
32. Ju MH, Huh JH, Lee CH, et al. Robotic-Assisted Surgical Ablation of Atrial Fibrillation Combined With Mitral Valve Surgery. Ann Thorac Surg 2019;107:762-8.
33. Yoon S, Kim K, Yoo JS, et al. Long-term outcomes of minimally invasive concomitant mitral and tricuspid valve surgery with surgical ablation. Interdiscip Cardiovasc Thorac Surg 2024;39:ivae146.

Cite this article as: Kim JY, Kim HR, Yoo JS, Kim JB, Jung SH, Lee JW, Kim HJ. Mitral valve surgery and maze procedure: the Korean experience in rheumatic versus degenerative disease. Ann Cardiothorac Surg 2026;15(1):5. doi: 10.21037/acs-2025-dmv-0157