J Korean Med Sci. 2024 Apr 22;39(15):e143
https://doi.org/10.3346/jkms.2024.39.e143
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article
Cardiovascular Disorders

Outcomes of Concomitant Maze Procedure in Tricuspid Repair for Severe Tricuspid Regurgitation

Ilkun Park,[1] **Suryeun Chung**,[1] **Yang Hyun Cho**,[1] **Kiick Sung**,[1] **Wook Sung Kim**,[1] **Kyungsub Song**,[2] **Joong Hyun Ahn**,[3] **Chang Seok Jeon**,[4] **Pyo Won Park**,[4] **and Dong Seop Jeong** [1]

[1]Department of Thoracic and Cardiovascular Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea
[2]Department of Thoracic and Cardiovascular Surgery, Dongsan Medical Center, Keimyung University School of Medicine, Daegu, Korea
[3]Biostatistics and Clinical Epidemiology Center, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea
[4]Department of Thoracic and Cardiovascular Surgery, Incheon Sejong Hospital, Incheon, Korea

Received: Aug 1, 2023
Accepted: Mar 26, 2024
Published online: Apr 15, 2024

Address for Correspondence:
Dong Seop Jeong, MD, PhD
Department of Thoracic and Cardiovascular Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea.
Email: cabg@korea.com

ORCID iDs
Ilkun Park
https://orcid.org/0000-0001-6005-640X
Suryeun Chung
https://orcid.org/0000-0002-9619-0640
Yang Hyun Cho
https://orcid.org/0000-0003-1685-3641
Kiick Sung
https://orcid.org/0000-0003-0768-9587
Wook Sung Kim
https://orcid.org/0000-0001-7808-3385
Kyungsub Song
https://orcid.org/0000-0002-6556-2261
Joong Hyun Ahn
https://orcid.org/0000-0002-5768-5990
Chang Seok Jeon
https://orcid.org/0000-0002-2833-6724
Pyo Won Park
https://orcid.org/0000-0002-0892-4107

ABSTRACT

Background: We aimed to analyze the impact of concomitant Maze procedure on the clinical and rhythm outcomes, and echocardiographic parameters in tricuspid repair for patients with severe tricuspid regurgitation (TR) and persistent atrial fibrillation (AF).
Methods: Patients who had severe TR and persistent AF and underwent tricuspid valve (TV) repair were included in the study. Both primary TR and secondary TR were included in the current study. The study population was stratified according to Maze procedure. The primary outcome was major adverse cardiovascular and cerebrovascular event (MACCE) at 15 years post-surgery. Propensity-score matching analyses was performed to adjust baseline differences.
Results: Three hundred seventy-one patients who underwent tricuspid repair for severe TR and persistent AF from 1994 to 2021 were included, and 198 patients (53.4%) underwent concomitant Maze procedure. The maze group showed 10-year sinus rhythm (SR) restoration rate of 55%. In the matched cohort, the maze group showed a lower cumulative incidence of cardiac death (4.6% vs. 14.4%, $P = 0.131$), readmission for heart failure (8.1% vs. 22.2%, $P = 0.073$), and MACCE (21.1% vs. 42.1%, $P = 0.029$) at 15 years compared to the non-maze group. Left atrial (LA) diameter significantly decreased in the maze group at 5 years (53.3 vs. 59.6 mm, $P < 0.001$) after surgery compared to preoperative level, and there was a significant difference in the change of LA diameter over time between the two groups ($P = 0.013$).
Conclusion: The Maze procedure during TV repair in patients with severe TR and persistent AF showed acceptable SR rates and lower MACCE rates compared to those without the procedure, while also promoting LA reverse remodeling.

Keywords: Tricuspid Regurgitation; Maze Procedure; Sinus Rhythm Restoration; Left Atrial Reverse Remodeling

INTRODUCTION

Concomitant Maze operation with mitral valve surgery or coronary artery bypass graft showed Maze success rate of 80–90%[1,2] and actively recommended despite a low

Dong Seop Jeong
https://orcid.org/0000-0002-6947-8403

Disclosure
The authors have no potential conflicts of interest to disclose.

Author Contributions
Conceptualization: Park I, Chung SR, Cho YH, Sung K, Kim WS, Song K, Park PW, Jeong DS. Data curation: Park I, Jeon CS, Ahn JH. Investigation: Park I, Jeon CS, Song K. Methodology: Park I, Ahn JH. Supervision: Jeong DS. Writing - original draft: Park I. Writing - review & editing: Jeong DS.

application rate in the real world. However, patients with severe tricuspid regurgitation (TR) and persistent atrial fibrillation (AF) are those that many surgeons are reluctant to do concomitant Maze operation due to various reasons, such as severe preoperative medical conditions,[3,4] prolonged surgery time due to concomitant left-sided valve surgery, low Maze success rate,[5] and a history of multiple cardiac surgeries. Thus, previous reports on the outcomes of Maze operations in these patients are extremely limited.[5]

The main limitations when conducting a study analyzing the clinical impact of concomitant Maze operation in severe TR and persistent AF are as follows: 1) The inherent high mortality and morbidity rates of tricuspid valve (TV) surgery may potentially diminish the clinical impact of Maze procedure,[6,7] 2) TV replacement has been associated with high perioperative and long-term mortality, as well as the potential to induce right ventricular dysfunction, which make the analysis more complicated,[7,8] 3) and many patients with severe TR also require concomitant left valve surgery, making it difficult to find out appropriate clinical and echocardiographic parameters.[9,10]

At the current institution, various strategies (including the full use of modified ultrafiltration during and after cardiopulmonary bypass (CPB), short CPB time, effort to minimize volume of postoperative blood loss and transfusion, and optimal postoperative body weight recovery) are used to improve the outcomes of TR surgery, with a 10-year survival rate of 70%.[11] Moreover, at our current institution, the Maze procedure has been actively performed on patients with severe TR and concomitant AF, even in cases involving multiple valve surgeries.[5]

Based on these, the current study aimed to analyze the impact of concomitant Maze procedures on clinical and rhythmic outcomes and echocardiographic parameters in patients who underwent tricuspid repair for severe TR and persistent AF.

METHODS

Study design and populations

This study included patients with severe TR and persistent AF who underwent TV repair at a single tertiary center between January 1994 and December 2021 (**Fig. 1**). Both primary TR and secondary TR were included in the current study. Persistent AF was defined as a non-self-limiting AF lasting > 7 or < 7 days if cardioversion was required according to the Heart Rhythm Society guidelines.[12] Patients who had concomitant congenital heart surgery other than atrial septal defect (ASD) closure, aortic surgery, or left ventricular assist device insertion were excluded from the analysis.

The primary objective was to evaluate major adverse cardiovascular and cerebrovascular events (MACCE), including cardiac-related mortality, heart failure readmissions, and stroke, at 15 years following the surgery. In patients who were lost to follow-up, mortality was confirmed utilizing data from the National Death Records.

Surgical procedure

The modified Cox Maze procedure was executed on chosen patients through a full median sternotomy, employing either antegrade or retrograde cardioplegia. The determination of performing the Maze procedure was influenced by several factors known to impact the restoration of sinus rhythm. These factors encompassed the size and fibrosis of the left

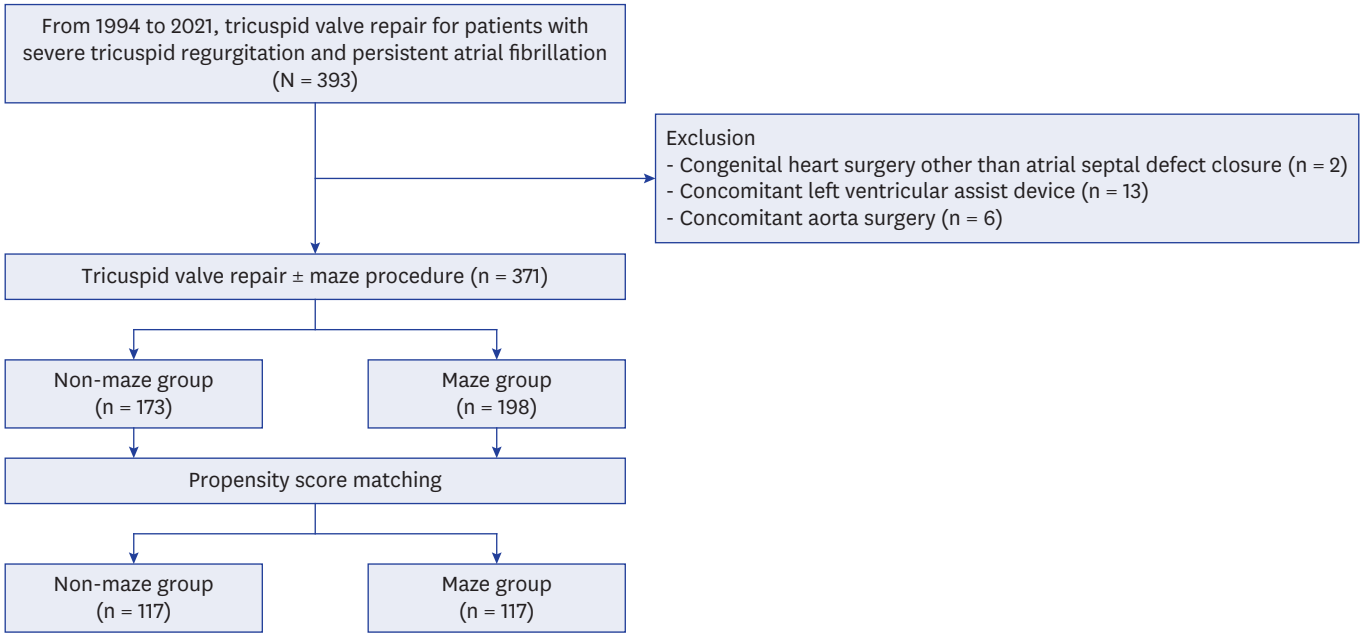

Fig. 1. Study flow diagram. A total of 371 patients who underwent TV repair for severe TR and persistent atrial fibrillation were enrolled. Patients were divided into maze and non-maze groups. After propensity score matching, 117 pairs of maze and non-maze group were matched.
TV = tricuspid valve, TR = tricuspid regurgitation.

atrium, the left atrial (LA) volume index, the duration of AF, combined procedures, and concerns related to anticoagulation. Nonetheless, the ultimate decision to proceed with the Maze procedure was at the discretion of the surgeon performing the operation.

The Maze procedure was conducted utilizing cryoablation with cryogenerators adjusted to −60°C for a duration of 2 minutes and 30 seconds in order to create transmural lesions, based on the principles outlined in previous studies.[13,14] The LA lesion set included three ablation lines, with the superior and inferior lines extending from the left atriotomy to the LA appendage for pulmonary vein isolation and the endocardial mitral line extending from the inferior part of the box lesion to the posterior annulus. Epicardial coronary sinus ablation was not performed as a routine. The right atrial (RA) lesion set consisted of three ablation lines, including the superior vena cava to the inferior vena cava lesion, T lesion from the intercaval lesion extending to the TV annulus, and RA appendage lesion from the right atriotomy extending to the TV annulus. In all Maze procedures, obliteration of the LA appendage was carried out internally, using a stapled exclusion, or through external resection, in accordance with the surgeon's preference.

Statistical analysis

The study used categorical variables, which were presented as frequency and percentage, and continuous variables, which were presented as mean plus standard deviation. The χ^2 test or Fisher's exact test was used to compare categorical variables between groups, while the two-sample *t*-test or the Wilcoxon rank-sum test was used to compare continuous variables. The normality of the continuous data was checked using the Shapiro-Wilk test and graphical methods. All statistical tests were two-sided with a significance level of 0.05. For event-free survival estimation, the Kaplan-Meier method was used, and the log-rank test was used to compare survival curves. In the presence of competing risks, the Fine and Gray competing

https://doi.org/10.3346/jkms.2024.39.e143

risk model was used to calculate the cumulative incidence function with a relative 95% confidence interval (CI).

The study utilized propensity score matching to adjust for differences in baseline characteristics between the control and maze groups in a 1:1 manner using the nearest-neighbor matching (**Supplementary Fig. 1**). The balance between the two groups was evaluated using the standardized mean difference, with a value of < 0.20 indicating that the variables were well-matched between the groups.

To determine if there was a relationship between time and groups for repeated measures, a linear mixed-effects model was used. For analyzing the predictors of clinical outcomes, the Cox proportional hazard regression was utilized for the entire patient population. In the univariable analysis, variables with a *P* value of less than 0.2 were considered for the multivariable analysis. The backward elimination method was used for model selection. The results were reported as a hazard ratio (HR) and 95% CI. The R statistical software version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analysis.

Ethics statement

The Institutional Review Board of Samsung Medical Center approved the current study, and informed consent was waived because the study was retrospective in nature with minimal patient risks (SMC 2022-08-120, approved on September 14, 2022).

RESULTS

During the study period, 371 patients who underwent tricuspid repair for severe TR and persistent AF were included, and 198 (53.4%) patients underwent concomitant Maze procedure (**Fig. 1**). The mean follow-up duration in all patients was 7.5 years.

Baseline characteristics

The patients had a mean age of 62.3 years, and 145 (39.1%) of them were males. Among them, 63 patients (16.9%) had a history of previous cardiac surgery, and 148 patients (39.8%) had New York Heart Association (NYHA) functional class 3 or higher before the surgery. Additionally, 150 (40.4%) patients had an left ventricle (LV) ejection fraction of < 55% before the surgery. The mean left atrial diameter (LAD) before surgery for all patients was 60.2 ± 11.1 mm, and the mean RA diameter was 56.2 ± 10.5 mm. Furthermore, 346 (93.3%) patients presented with RA enlargement, and 358 (96.5%) with LA enlargement. Concomitant left-sided valve surgeries were performed in 324 patients (87.3%).

The maze and non-maze groups were similar in terms of age, sex, NYHA functional classification, and preoperative critical status (**Table 1**). However, the non-maze group had a greater rate of previous cardiac surgery (28.3% vs. 7.1%, *P* < 0.001) and a larger LAD (63.1 vs. 57.6 mm, *P* < 0.001) compared with the maze group. Related to concomitant cardiac surgeries including valve surgery, ASD closure, and coronary artery bypass grafting (CABG), there were no statistical differences between the maze group and the non-maze group (**Supplementary Table 1**).

https://doi.org/10.3346/jkms.2024.39.e143

Table 1. Baseline and operative characteristics

Variables	Total patients			Propensity-matched patients		
	Non-maze group (n = 173)	Maze group (n = 198)	*P* value	Non-maze group (n = 117)	Maze group (n = 117)	SMD
Age > 60 years	111 (64.2)	124 (62.6)	0.843	74 (63.2)	71 (60.7)	0.035
Male sex	67 (38.7)	78 (39.4)	0.981	78 (66.7)	72 (61.5)	0.107
Comorbidities						
Diabetes mellitus	28 (16.2)	33 (16.7)	> 0.999	20 (17.1)	19 (16.2)	0.023
Hypertension	36 (20.8)	55 (27.8)	0.151	26 (22.2)	29 (24.8)	0.060
Renal disease with dialysis	5 (2.9)	8 (4.0)	0.750	4 (3.4)	6 (5.1)	0.085
Previous cerebrovascular accident	22 (12.7)	23 (11.6)	0.869	14 (12.0)	14 (12.0)	< 0.001
Coronary artery disease	10 (5.8)	8 (4.0)	0.592	5 (4.3)	6 (5.1)	0.040
Previous cardiac surgery	49 (28.3)	14 (7.1)	< 0.001	12 (10.3)	13 (11.1)	0.028
NYHA functional class			0.154			0.166
1	35 (20.2)	41 (20.7)		28 (23.9)	27 (23.1)	
2	64 (36.9)	83 (41.9)		43 (36.8)	45 (38.5)	
3	53 (30.6)	63 (31.8)		34 (29.1)	38 (32.5)	
4	21 (12.1)	11 (5.6)		12 (10.3)	7 (6.0)	
Active infective endocarditis	2 (1.2)	1 (0.5)	0.906	1 (0.9)	1 (0.9)	< 0.001
Extracardiac arteriopathy	8 (4.6)	4 (2.0)	0.263	2 (1.7)	3 (2.6)	0.059
Chronic lung disease	9 (5.2)	12 (6.1)	0.895	6 (5.1)	7 (6.0)	0.037
Preoperative critical status	21 (12.1)	13 (6.6)	0.094	12 (10.3)	11 (9.4)	0.029
Preoperative echography						
Ejection fraction, %	55.1 ± 11.6	56.5 ± 8.9	0.197	54.9 ± 11.7	56.4 ± 8.9	0.166
< 55%	74 (42.8)	76 (38.4)	0.451	50 (42.7)	46 (39.3)	
Left atrial diameter, mm	63.1 ± 11.4	57.6 ± 10.3	< 0.001	60.9 ± 8.7	59.6 ± 11.2	
Left atrial enlargement	170 (98.3)	188 (96.4)	0.440	116 (99.1)	114 (97.4)	
RA enlargement	160 (92.5)	186 (94.4)	0.589	111 (94.9)	110 (94.0)	
Mitral stenosis	48 (27.8)	42 (21.2)	0.179	36 (30.8)	29 (24.8)	< 0.001
Mitral regurgitation	68 (39.3)	74 (37.8)	0.783	49 (41.9)	40 (34.2)	0.059
Aortic stenosis	19 (10.9)	10 (5.1)	0.054	15 (12.8)	7 (6.0)	0.037
Aortic regurgitation	10 (5.8)	15 (7.6)	0.631	7 (6.0)	11 (9.4)	0.029
Operative characteristics						
Type of surgery			0.111			0.186
Elective	166 (95.9)	196 (98.9)		114 (97.4)	115 (98.3)	
Urgent	6 (3.5)	1 (0.5)		3 (2.6)	1 (0.9)	
Emergent	1 (0.6)	1 (0.5)		0 (0)	1 (0.9)	
Concomitant procedure			0.961			0.170
0	55 (31.8)	61 (30.8)		36 (30.8)	41 (35.0)	
1	74 (42.8)	85 (42.9)		52 (44.4)	44 (37.6)	
2	41 (23.7)	47 (23.7)		27 (23.1)	28 (23.9)	
3	3 (1.7)	5 (2.5)		2 (1.7)	4 (3.4)	
CPB time, min	149.5 ± 62.1	158.3 ± 53.0	0.183	136.7 ± 45.1	164.7 ± 58.4	0.536
ACC time, min	105.7 ± 47.8	120.6 ± 40.9	0.003	99.4 ± 38.6	125.4 ± 44.5	0.625

Data are expressed as number (%) or mean ± standard deviation values.
SMD = standardized mean difference, NYHA = New York Heart Association, CPB = cardiopulmonary bypass, ACC = aortic cross-clamp.

Clinical outcomes

The 15- and 20-year survival rates for patients who underwent TR repair were 73.1% and 71.3%, respectively (**Supplementary Fig. 2**). In the matched cohort, the 15-year survival rate was 77.5% in the maze group and 74.2% in the non-maze group, without statistical significance ($P = 0.97$).

In the matched cohort, the maze group had a lower cumulative incidence of cardiac-related mortality (4.6% vs. 14.4%, $P = 0.131$), HF-related readmission (8.1% vs. 22.2%, $P = 0.073$), and MACCE (21.1% vs. 42.1%, $P = 0.029$) at 15 years compared with the non-maze group (**Fig. 2**, **Supplementary Table 2**). Further, the maze group had a lower cumulative incidence of stroke (10.4% vs. 16.7%, $P = 0.489$) and TR more than moderate (19% vs. 25%, $P = 0.475$)

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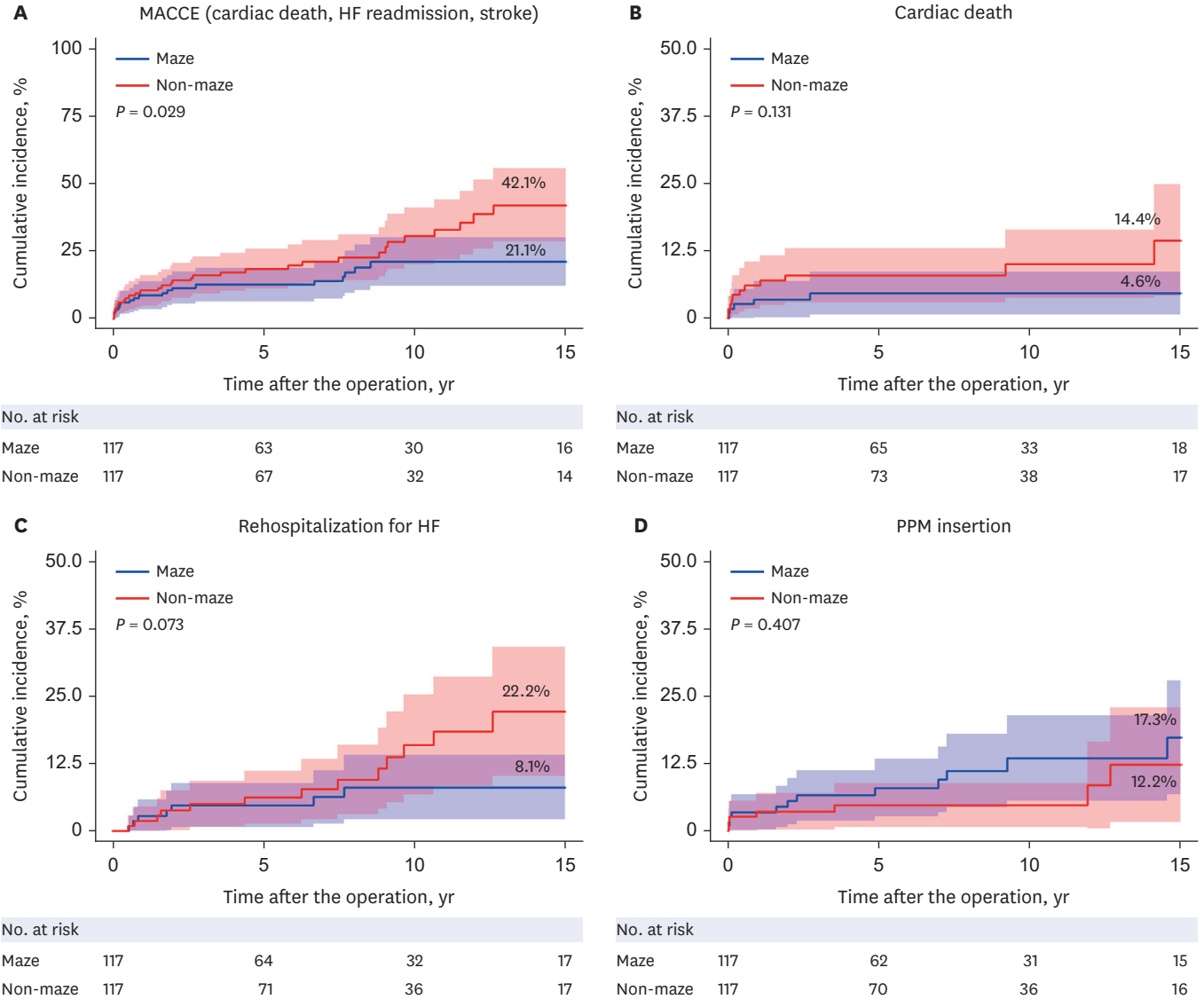

Fig. 2. Cumulative incidence curves for MACCE (**A**), cardiac death (**B**), rehospitalization for HF (**C**), and PPM insertion (**D**) according to Maze procedure in the propensity-score matched cohort. All-cause death or non-cardiac death was accounted as a competing event in the Fine-Gray model.
MACCE = major adverse cardiovascular and cerebrovascular events, HF = heart failure, PPM = permanent pacemaker.

at 20 years compared with the non-maze group, although without statistical significance (**Supplementary Fig. 3**, **Supplementary Table 2**). Further, there was no statistically significant difference between the two groups in terms of permanent pacemaker (PPM) insertion.

In the multivariable analysis (**Table 2**), the Maze procedure was an independent prognostic factor for MACCE (HR, 0.548; 95% CI, 0.357–0.840; $P = 0.006$) and cardiac death (HR, 0.415; 95% CI, 0.190–0.906; $P = 0.027$).

Rhythm and echocardiographic outcomes

In the total cohort, the maze group showed 10-year maze success rate of 55% and the non-maze group had 10-year sinus rhythm restoration rate of 10% (**Fig. 3**). In the multivariable analysis (**Table 2**), Maze procedure (HR, 7.671; 95% CI, 3.608–17.571; $P < 0.001$), preoperative

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Table 2. Multivariable cox regression analysis

Variables	Multivariable-adjusted model	
	HR (95% CI)	*P* value
MACCE		
Maze procedure	0.548 (0.357–0.840)	0.006
Old age (> 60 yr)	1.487 (0.938–2.358)	0.091
Diabetes mellitus	1.606 (0.947–2.725)	0.079
Chronic lung disease	1.886 (0.860–4.135)	0.113
Preoperative ejection fraction < 55%	1.528 (0.998–2.340)	0.051
Cardiac death		
Maze procedure	0.415 (0.190–0.906)	0.027
Old age > 60 yr	2.116 (0.975–4.592)	0.058
Preoperative critical status	4.243 (1.973–9.125)	< 0.001
Preoperative ejection fraction < 55%	2.684 (1.247–5.777)	0.012
Rehospitalization for HF		
Maze procedure	0.559 (0.294–1.063)	0.076
Old age > 60 yr	2.085 (0.998–4.355)	0.050
Diabetes mellitus	2.120 (1.005–4.470)	0.048
Chronic lung disease	2.588 (0.901–7.434)	0.077
Postoperative sinus rhythm restoration[a]		
Maze procedure	7.671 (3.608–17.571)	< 0.001
Old age > 60 yr	0.513 (0.260–0.999)	0.051
Previous cardiac surgery	0.451 (0.154–1.232)	0.129
Preoperative left atrial diameter	0.953 (0.925–0.981)	0.001
Preoperative RA diameter	0.927 (0.895–0.957)	< 0.001

HR = hazard ratio, CI = confidence interval, MACCE = major adverse cardiovascular and cerebrovascular events, HF = heart failure.
[a]This was analyzed by multiple logistic regression model.

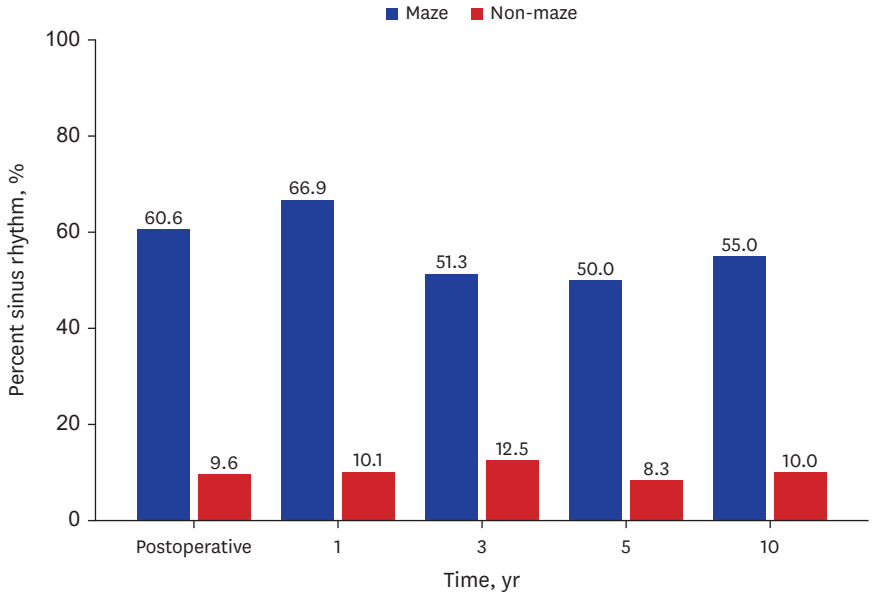

Fig. 3. Sinus rhythm restoration rate between the maze and the non-maze groups in the total patients.

LAD (HR, 0.953; 95% CI, 0.925–0.981; $P = 0.001$), and preoperative RA diameter (HR, 0.927; 95% CI, 0.895–0.957; $P < 0.001$) were independent prognostic factors for postoperative sinus rhythm restoration.

Related to echocardiographic outcomes (**Table 3**, **Fig. 4**), there were no significant differences over time in terms of LV end-diastolic diameter, LV end-systolic diameter, tricuspid annular

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Table 3. Echocardiographic outcomes in the matched cohort

Variables	Preoperative (n = 291)	5-year follow-up (n = 132)	10-year follow-up (n = 87)	*P* values[a]
LV end-diastolic diameter, mm				0.514
Maze group	49.7 ± 9.3	51.9 ± 5.9	51.2 ± 5.9	
Non-maze group	52.9 ± 10.8	53.7 ± 6.4	52.2 ± 6.2	
LV end-systolic diameter, mm				0.719
Maze group	30.8 ± 6.4	33.4 ± 5.6	32.9 ± 5.7	
Non-maze group	33.4 ± 7.2	35.0 ± 7.9	33.9 ± 6.5	
LV ejection fraction, %				0.212
Maze group	61.3 ± 5.6	59.2 ± 8.4	61.0 ± 4.3	
Non-maze group	60.4 ± 8.5	62.6 ± 7.4	61.9 ± 5.2	
TAPSE, mm				0.160
Maze group	16.7 ± 4.7	11.8 ± 3.2	11.7 ± 2.4	
Non-maze group	14.7 ± 3.5	12.2 ± 2.9	13.1 ± 5.2	
LAD, mm				0.013
Maze group	59.6 ± 11.4	53.3 ± 8.4	54.9 ± 10.8	
Non-maze group	61.3 ± 10.6	59.6 ± 12.5	58.8 ± 12.3	

Data are expressed mean ± standard deviation values.
LV = left ventricle, TAPSE = tricuspid annular plane systolic excursion, LAD = left atrial diameter.
[a]Linear mixed model was used to assess the interaction between time and group.

plane systolic excursion and LV ejection fraction between the maze and non-maze groups at baseline and 5 and 10 years after surgery. The LAD did not significantly change over time in the non-maze group. However, it decreased significantly in the maze group at 5 years (53.3 vs. 59.6 mm, $P < 0.001$) and 10 years (54.9 vs. 59.6 mm, $P = 0.086$) after surgery. Hence, there were significant differences in LAD changes between the two groups over time ($P < 0.001$ in the linear mixed model).

DISCUSSION

The present study revealed the following key findings. First, the 10-year Maze success rate in patients who underwent TR repair was 55%. Second, patients undergoing the Maze procedure experienced fewer MACCEs than those who did not receive the concurrent Maze operation. Third, the Maze procedure also resulted in LA reverse remodeling.

Compared with mitral valve surgeries or CABG, patients with severe TR and persistent AF generally had a lower Maze success rate.[1,2,5,15] This can be attributed to the fact that these patients commonly have multiple valvular heart disease, biatrial enlargements and history of cardiac surgery. These factors combined with poor preoperative medical conditions and high PPM insertion rate[5,7,16,17] may contribute to the fact that surgeons are reluctant in performing Maze operations in such patients. A previous study proposed appropriate cutoff values for LA and RA to address this issue.[5]

To determine the clinical impact of concomitant Maze procedure in patients with TR, it is crucial to identify the relevant outcomes in this study cohort.[9,10] As TR is a long-term process, not only hard endpoints including cardiac death, but soft endpoints such as rehospitalization, quality of life, functional status, or secondary hemodynamic parameters such as right ventricular function and pulmonary artery pressure might also be important to evaluate the impact of Maze procedure.[10] Our research incorporated these additional parameters to gain a deeper understanding of its benefits for patients with severe TR.

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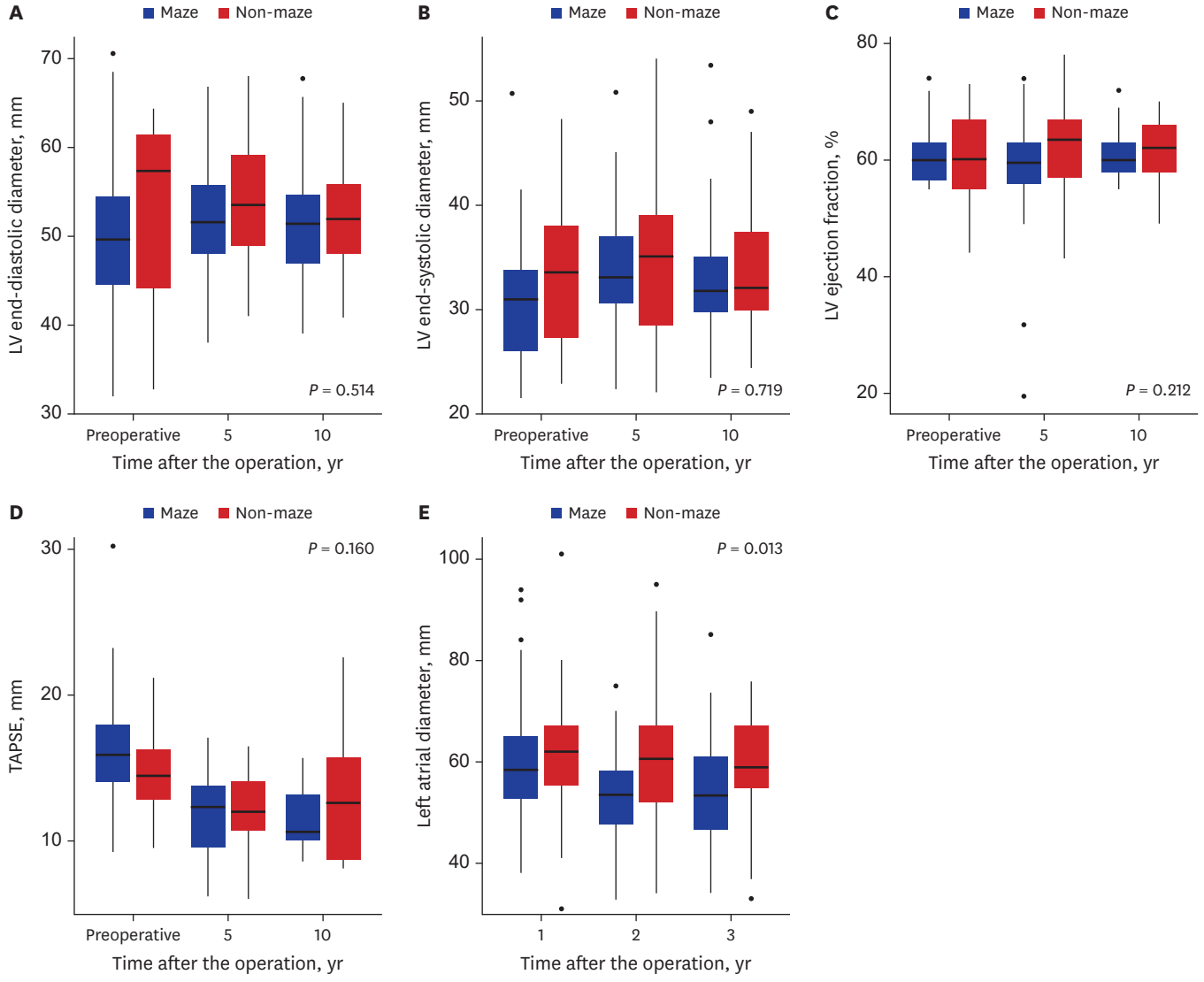

Fig. 4. Serial changes in LV end-diastolic diameter (**A**), LV end-systolic diameter (**B**), LV ejection fraction (**C**), TAPSE (**D**), and LAD (**E**) according to the Maze procedure. The horizontal line in the middle of each box indicates the median; the top and bottom borders of the box mark the 75th and 25th percentiles, respectively; and the top and bottom ends of the whiskers extend from the box to the furthest data points within 1.5 times the interquartile range from the quartiles, encompassing the range of the data excluding outliers. Linear mixed model was used to assess interaction between time and group.
LV = left ventricle, TAPSE = tricuspid annular plane systolic excursion, LAD = left atrium diameter.

Surgery for severe TR historically demonstrates high perioperative and long-term mortality rates. According to a previous study,[7] the 10-year survival rate of patients who underwent TV replacement is 29%, and the 15-year survival rate is 12%. Meanwhile, another report revealed that the 10-year survival rate of the repair group was 49%.[6] Further, our data showed that the survival rates of these patients were 73.1% at 15 years and 71.3% at 20 years. Importantly, our study excluded patients with TV replacements, narrowing our focus to a clear assessment of the Maze procedure's impact on severe TR. The noteworthy aspect is that patients who underwent the Maze procedure had a significantly lower MACCE rate, compared to those who did not receive Maze procedure. Atrial fibrillation can decrease cardiac output due to the loss of mechanical atrial contraction and rapid ventricular rate. However, the Maze operation can increase cardiac output by restoring and maintaining sinus rhythm in approximately 50% of the patients. In addition, late TR progression might also be slowed down by the Maze procedure.[18,19]

https://doi.org/10.3346/jkms.2024.39.e143

Another interesting point is that LAD, which is commonly used as indicators of LA remodeling, significantly decreased after the Maze procedure.[20] The preoperative LA remodeling in these patients could have been due to LV diastolic dysfunction-induced structural remodeling and electrical remodeling caused by AF.[20] However, the non-maze group showed no significant differences in LAD after valve surgeries, while the significantly increased LAD decreased notably after the concomitant maze operation in the maze group. This suggests that electrical reverse remodeling may be possible even in a significantly enlarged LA through the Maze procedure. Although LA reverse remodeling after catheter ablation or cardiac resynchronization therapy for AF has been extensively reported,[21-23] LA reverse remodeling after the Maze procedure is rarely reported. Improving the Maze success rate through appropriate patient selection[5] may lead to better LA reverse remodeling.

The current study had several limitations that should be considered. First, the generalizability of the findings could have been limited by the study's retrospective design and small sample size. Additionally, while propensity score matching was performed to include all known variables in an attempt to make an equitable comparison between the maze group and the non-maze group, there may be other variables not included (such as left atrial volume index [LAVI], RA diameter, etc.), which could have influenced the outcomes. Second, both primary TR and secondary TR were analyzed together. However, in a real-world setting, the majority of TR cases are secondary TR, similar to the cohort in this study. This fact is not believed to undermine the significance of the conclusions drawn from this study. Finally, data on LAVI measurements were only available from 2004 onward. Thus, propensity score matching was performed using LAD as a surrogate for LA remodeling, which could introduce potential biases and limit the result accuracy. In addition, more advanced imaging techniques such as three-dimensional echocardiography or magnetic resonance imaging could have yielded more accurate LAVI measurements.[24]

In conclusion, the Maze procedure during TV repair in patients with severe TR and persistent AF showed acceptable SR rates and lower MACCE rates compared to those without the procedure, while also promoting LA reverse remodeling.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Concomitant procedures

Supplementary Table 2
Postoperative clinical outcomes

Supplementary Fig. 1
Balance between matched and unmatched data. (**A**) Mirror plot. (**B**) Love plot.

Supplementary Fig. 2
Time to event curves for clinical outcomes. (**A**) The rate of freedom from all-cause death, (**B**) all-cause death according to the Maze procedure in total patients, (**C**) all-cause death according to the Maze procedure in propensity score-matched patient, and (**D**) the cumulative incidence of non-cardiac death in the matched cohort. Cardiac death was accounted as a competing event in the Fine-Gray model.

https://doi.org/10.3346/jkms.2024.39.e143

Supplementary Fig. 3

Cumulative incidence curves for stroke (**A**), major bleeding (**B**), reoperation for TR (**C**), and more than moderate TR (**D**) according to maze procedure in the propensity-score matched cohort. All-cause death was accounted as a competing event in the Fine-Gray model.

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