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Article

Island Flap Rotation Technique as a Novel Repair Surgery Method for Severe Degenerative Mitral Valve Regurgitation

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Abstract

Background: The current study was done to assess the efficacy and safety of the island flap rotation technique as a novel method for severe mitral valve regurgitation. **Methods**: Twenty-three patients were selected to undergo mitral valve repair with the island flap rotational technique. It takes the principle of doing quadrangular resection of the P2 leaflet and flipping the dissected area so that the ruptured primary chordae are replaced with the secondary or tertiary chordae. Transesophageal echocardiography parameters were evaluated before surgery and 1 week after surgery, just prior to discharge. **Results**: The procedure was done successfully with 100% mitral regurgitation reduction to $\leq$1+ along with significantly reduced left ventricular end-diastolic diameter (p = 0.001) and left atrial dimension (p = 0.000). The left ventricular ejection fraction was significantly reduced after the procedure (p = 0.000). Older age significantly affects the presence of residual mitral regurgitation (p = 0.02). No thromboembolic adverse events and mortality were observed during the 3-month follow-up. **Conclusions**: The use of island flap rotation technique as a novel method for severe mitral regurgitation with P2 lesions has been proven to be effective and safe with preserving the valve tissue.

Keywords

mitral regurgitation; mitral valve repair; valve surgery; novel method; island flap rotation

Introduction

Mitral regurgitation (MR) is the most prevalent valvular disorder with prolapse of the mitral valve as the primary cause of MR requiring surgery. Mitral valve repair (MVr) in patients with severe primary MR has been shown to have a lower mortality rate, increased long-term survival, improved quality of life, and lower risk compared to mitral valve replacement (MVR) [1]. However, study found that re-operation rate after mitral valve repair reaches up to 26%, and 74% of degenerative valve disease re-operation is thought to be caused by multiple factors such as suture or annuloplasty dehiscence, chordae shortening, incomplete correction, systolic anterior motion, hemolysis, and ventricular remodeling [2]. Several common techniques of mitral valve repair such as triangular or quadrangular resection usually discard the affected leaflet, which may lead to tension and increase the probability of suture dehiscence [1]. The island flap rotation is a novel MVr technique aimed to refine the previously used techniques. It takes the principle of quadrangular resection and flipping the dissected area so that the ruptured primary chordae are replaced with the secondary or tertiary chordae. This technique utilizes the patient's existing chordae without discarding any tissue, resulting in no tension and less risk of suture dehiscence. It could accommodate the challenge present in developing countries where artificial chordae are unavailable. The present study reports the initial result of island flap rotation technique in 23 patients.

Material and Methods

Study Population

This non-randomized prospective study was designed to test the effectiveness and safety of island flap rotation technique in severe degenerative MR. From 2022–2023, twenty-three patients were selected to undergo MVr with island flap rotational technique.

Trans-esophageal echocardiography (TEE) was performed preoperatively to determine patient eligibility, MR

grades, and jet origin. The following were the inclusion criteria: (a) age between 18–70 years old, (b) severe degenerative MR of the P2 leaflet, (c) no history of prior heart surgery, (d) left ventricular ejection fraction (LVEF) >35% and Tricuspid Annular Plane Systolic Excursion (TAPSE) >15 mm. The exclusion criteria were as follows: (a) leaflet anatomy that might hinder the procedure, (b) a re-operation surgery, and (c) creatinine >2 mg/dL. MR grading was performed using the standard criteria and was classified into none (grade 0), mild (grade 1+), moderate (grade 2+), and severe (grade 3+). LVEF was assessed with biplane Simpson method using transesophageal echocardiography (TEE) and all other echocardiographic parameters were analyzed based on American Society of Echocardiography (ASE) recommendations [2].

All patients were closely monitored in the intensive care unit (ICU) and were given ventilatory support postoperatively. After the patients were considered hemodynamically stable, they were moved to the general ward and eventually discharged. Postoperative TEE was performed before discharge. The left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), left atrial (LA) dimension, LVEF, mean transmitral gradient and residual MR were measured. Procedural success, complications, and mortality were analyzed. A successful procedure was defined as having mild to no residual MR. Thromboembolic adverse events and mortality were observed during the 3-month follow-up.

This study was approved by the Institutional Review Board and the Ethics Committee of the National Cardiovascular Center Harapan Kita (No. LB.02.01/VII/001/KEP001/2022) and consent from the patients was obtained. The study was conducted under the principles of the Declaration of Helsinki.

Procedure

The procedure was performed under general anesthesia, the patients underwent median sternotomy, and a cardiopulmonary bypass (CPB) machine was established. The mitral valve was made visible through the left atrium (LA) or transseptal approach. Quadrangular resection of the P2 leaflet was performed in the shape of a square (from this point will be referred to as an island flap), as illustrated (Fig. 1). Later, the most intact, thick, and strong one between secondary or tertiary chordae available on the edge of the island flap will be chosen as the new primary chordae. Meanwhile the other ruptured or damaged chordae will be resected and discarded, left the island flap with well functioned chordae only. The island flap was then rotated to make the chosen neo-chordae position change and consequently became the primary chordae, therefore replacing the previously damaged or even ruptured chordae. The handling of the tissue is done with fine forceps. The surgeon sutured the island flap to close the defect without removing any tissue and performed plications on the free edge of the MV leaflet internally using continuous sutures to flatten the new free-edge leaflets. This was followed by implanting a ring annuloplasty (Fig. 2). After performing a re-evaluation by saline test to ensure the competency of the valve, LA or right atrium (RA) was closed, the aortic cross-clamp (AoX) was removed, and the CPB was weaned until stopped. Intraoperative TEE was performed to assess the adequacy of MV repair.

Table 1. Demographic and baseline characteristics.

Parameters	Mean ± SD
Gender n (%)	
Male	8 (35%)
Female	15 (65%)
Age (years)	51.39 ± 8.60
Weight (kg)	62.53 ± 13.02
Height (cm)	159.22 ± 8.32
CPB time (minutes)	87 (21)
AoX time (minutes)	68 (14)
Length of ICU stay (hours)	23 (8)
Ventilatory time (hours)	17 (6)
Length of ward stay (days)	6 (1)
Other procedures	
CABG	1
TVr	4

SD, Standard Deviation; CPB, Cardiopulmonary bypass; AoX, Aortic cross-clamp; ICU, Intensive care unit; CABG, Coronary artery bypass procedure; TVr, Tricuspid valve repair.

Statistical Analysis

Categorical variables were presented as frequencies and percentages. Continuous variables were presented as mean ± Standard Deviation (SD) or median (interquartile range). Data distribution was analyzed by the Shapiro-Wilk test. Comparison of continuous variables between baseline and post-procedure were compared with paired *t*-test or Wilcoxon test. Comparison between factors affecting residual MR 0/1+ were analyzed with independent sample *t*-test or Mann-Whitney test. MR grades were measured as a categorical variable. Every *p*-value was two-tailed, and a value of $p < 0.05$ was regarded as statistically significant. SPSS version 19 (SPSS Inc., Chicago, IL, USA) was used for the statistical analyses.

Results

Patients' Characteristics

Most patients were female with mean age of 51.39 ± 8.60 years. The median CPB time and AoX time were 87

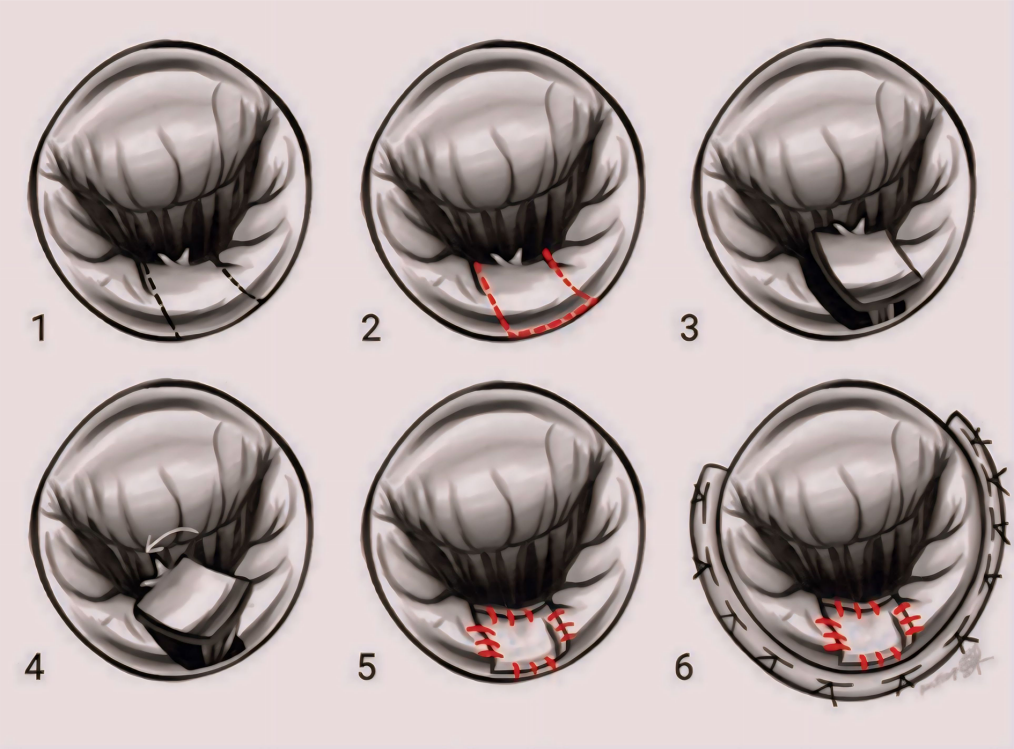

Fig. 1. The steps of island flap rotation technique. Black dashed line in Fig. 1-1 indicated the affected P2 leaflet area. Red dashed line in Fig. 1-2 indicated the area to be resected as the "island flap". White arrow in Fig. 1-4 indicated rotation movement of island flap to switch the damaged chordae position with neo-chordae.

(21) minutes and 68 (14) minutes, respectively. The median length of ICU stay was 23 (8) hours and the median ventilatory time was 17 (6) hours. The median length of ward stay was 6 (1) days. Associated procedures performed include coronary artery bypass graft and tricuspid valve repair (Table 1).

Echocardiographic Results

Of 23 patients, MR was absent (grade 0) in 9 patients and mild (grade 1+) in 14 patients. After the procedure, there is a significant reductions of the LVEDD ($p = 0.001$), LA dimension ($p = 0.000$), and LVEF ($p = 0.000$). LVESD was also found reduced in our study, but its statistically insignificant ($p = 0.07$). The median of the mean trans mitral valve gradient after the procedure was 2.00 (2.00) mmHg (Table 2).

Safety Outcomes

The perioperative period was uneventful. One patient required a reoperation from postoperative bleeding, and another required a debridement surgery due to prolonged thoracic wound healing with wound dehiscence. During the three-month follow-up, no thromboembolic adverse events or death were observed.

Discussion

MVr aims to minimize tension on any part of the valve and achieve a result that is very much like the physiologic pattern of valve opening and closing. It is now preferable to treat posterior leaflet prolapse without resecting any tissue [3]. The island flap rotation is a novel MVr technique that can act as an alternative to the currently available techniques. Unlike other resection techniques, island flap rotation does not remove any tissue, thus, preventing tension on the mitral valve. This technique only used the patient's own tissue without using any artificial replacement, such as Gore-Tex chordae, and can be considered cost-effective. Annuloplasty is performed at the end of the procedure. The procedure is also considered time effective with CPB and AoX time is still within the acceptable range.

The feasibility and short-term efficacy of the island flap rotation technique in treating degenerative MR have been shown. The procedure was done successfully with 100% MR reduction to $\leq$1+ along with significantly reduced LVEDD ($p = 0.001$) and LA dimension ($p = 0.000$). A study by Imielski *et al.* [4] showed freedom from MV reoperation in patients with residual MR of 0 was 99.5% and in patients with residual MR of 1+ was 97% at 5 years. It is known that the majority of mild residual MR might decrease to trivial or no MR, and some might persist. There

Table 2. Echocardiographic results.

	Baseline	Post-procedure	*p*
LVEDD (mm)	59.40 (9.70)	49.00 (8.00)	0.001[w]
LVESD (mm)	36.25 ± 6.02	33.41 ± 7.41	0.076[tt]
LA dimension (mm)	49.87 ± 8.25	40.10 ± 7.16	0.000[tt]
LVEF (%)	67.78 ± 6.73	54.47 ± 12.59	0.000[tt]
Mean trans mitral gradient (mmHg)	-	2.00 (2.00)	
MR grade n (%)			
0	-	9 (39%)	
+1	-	14 (61%)	
+2	-	-	
+3	23 (100%)	-	

LVEDD, Left ventricular end-diastolic diameter; LVESD, Left ventricular end-systolic diameter; LA, Left atrium; LVEF, Left ventricle ejection fraction; MR, Mitral regurgitation; w, Wilcoxon; tt, paired *t*-test.

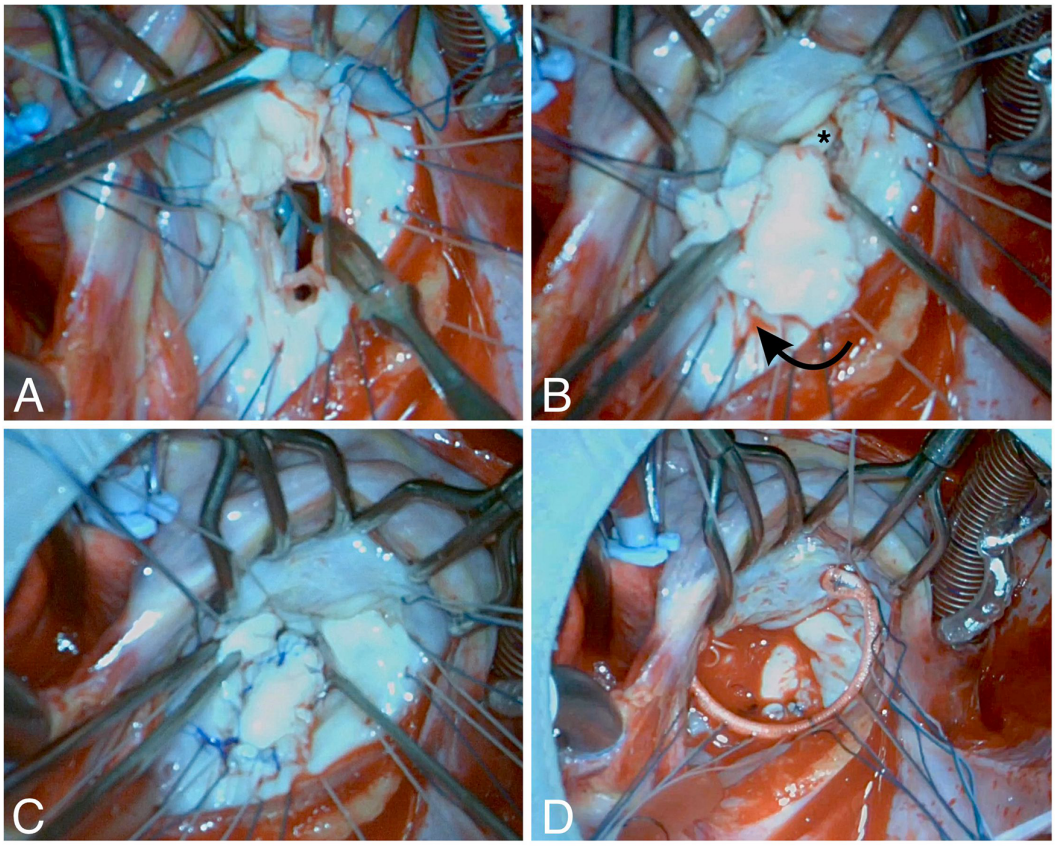

Fig. 2. Island flap rotation technique steps. (A) Quadrangular resection of P2 leaflet (Island flap). (B) Rotation of the island flap. (C) Island Flap sutured. (D) Annuloplasty; *previously secondary/tertiary chordae that serves as primary chordae after the rotation.

are no evident echocardiographic parameters that can predict residual MR progression. However, due to our non-randomized study design, further study is still needed to improve the implication of generalizability of the intervention.

The finding in our study showed a significant reduction of LVEF on post-procedure. Theoretically, the decrease in LVEF immediately after MVr can be attributed to a decrease in preload, an increase in afterload, or a decrease in contractility of left ventricle. Several other studies also showed similar findings, and it is believed that the elimination of regurgitant volume induces early left ventricular reverse remodeling, which subsequently caused the decrease in left ventricular end-diastolic volume (LVEDV) and LVEF [4,5]. Although significant decrease in LVEF was found, multiple studies showed most patients has progressive improvement of LVEF to the lower normal range of LVEF at late follow-up, and even gradually increase until reached a plateau at 60% [4,6,7]. The improvement in-

Table 3. Factors affecting residual MR.

	No Residual MR	Residual MR 1+	*p*
Age (years)	46.33 (8.84)	54.64 (6.92)	0.020[tt]
AoX time (minutes)	67.00 (11)	73.00 (15)	0.614[mw]
CPB time (minutes)	87.00 (18)	88.00 (33)	0.508[mw]

CPB, Cardiopulmonary bypass; AoX, Aortic cross clamp; tt, independent sample *t*-test; mw, Mann-Whitney.

dicated enhanced coaptation with improved contractility. Thus, although the majority of patients (61%) had residual MR of 1+, it was unlikely that these conditions would advance later to become moderate or severe [4,7]. A significant decline in LVEDD was also observed, indicating a better functional result compared to having persistent postoperative LV enlargement [5].

Our study showed that patients with residual MR were older compared to those with no residual MR ($p = 0.02$) (Table 3). Fibroelastic deficiency in older age is thought to be the reason. Reduced elastin and collagen composition in leaflets and chordae caused it to stiffen and thicken, leading to less optimal results after repair [4–6,8,9]. The surgeon's experience and familiarity with the procedure may also play a role. Meanwhile, other factors observed in the study such as higher aortic cross clamp and cardiopulmonary bypass time was found insignificant in affecting the residual MR in study population, with *p* value of 0.61 and 0.508 respectively (Table 3).

The postoperative mean transmitral gradient should be considered in MVr to minimize the potential of mitral stenosis. Some degree of valve orifice narrowing is inevitable in most repairs [4]. It is also known that tissue resection can further elevate mitral gradient (EMG) after MVr [8]. Thus, the principles of "respect when you can, resect when you should" are implemented in the current study [9]. The degree of mitral stenosis shortly after the procedure was caused by intrinsic factors of the repair procedure itself. No prior studies are available regarding EMG in patients with degenerative MVr. According to Chan *et al*. [9], a mean transmitral gradient of >3 mmHg is abnormal and may indicate mitral stenosis [8]. The median mean transmitral gradient in this study was 2.00 (2.00) mmHg indicating no mitral stenosis was present.

Limitation

Further follow-up study needs to be done to evaluate the long-term efficacy, safety, and complication of the island flap rotation technique. A comparison study is beneficial to determine whether the current technique is on par with the other widely used techniques. As this study is conducted non-randomized, continual study with randomization is still needed to improve the implication of generalizability of the intervention.

Conclusions

The use of island flap rotation technique as a novel method for severe mitral regurgitation with P2 lesions has been proven to be effective and safe with preserving the valve tissue.

Availability of Data and Materials

All data points generated or analyzed during this study are included in this published article.

Author Contributions

AT, TWS, AMS, RS, SS, and BS designed the research study. AT performed the island flap rotation technique and TWS assisted the surgery. AMS performed the transesophageal echocardiography (TEE) examination and provided advice on the research. RS, SS, and BS assisted the TEE examination and the research study. WAS and MM provided data analysis and interpretation. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board and the Ethics Committee of the National Cardiovascular Center Harapan Kita (No. LB.02.01/VII/001/KEP001/2022) and consent from the patients was obtained. The study was conducted under the principles of the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] El Sabbagh A, Reddy YNV, Nishimura RA. Mitral Valve Regurgitation in the Contemporary Era: Insights Into Diagnosis, Management, and Future Directions. JACC. Cardiovascular Imaging. 2018; 11: 628–643.

[2] Moore RA, Wierup P, Tappuni S, Houghtaling PL, Burns DJP, Chemtob R, *et al*. Reoperation after early and late failure of mitral valve repair for degenerative disease. The Journal of Thoracic and Cardiovascular Surgery. 2024; 167: 1251–1262.e8.

[3] Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, *et al*. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Journal of the American Society of Echocardiographyy. 2015; 28: 1–39.e14.

[4] Imielski B, Malaisrie SC, Pham DT, Kruse J, Andrei AC, Liu M, *et al*. The impact of intraoperative residual mild regurgitation after repair of degenerative mitral regurgitation. The Journal of Thoracic and Cardiovascular Surgery. 2021; 161: 1215–1224.e4.

[5] Joung KW, Kim SO, Nam JS, Moon YJ, Bae HJ, Chin JH, *et al*. Changes in Left Ventricular Ejection Fraction after Mitral Valve Repair for Primary Mitral Regurgitation. Journal of Clinical Medicine. 2021; 10: 2830.

[6] van Wijngaarden AL, Kruithof BPT, Vinella T, Barge-Schaapveld DQCM, Ajmone Marsan N. Characterization of Degenerative Mitral Valve Disease: Differences between Fibroelastic Deficiency and Barlow's Disease. Journal of Cardiovascular Development and Disease. 2021; 8: 23.

[7] Dreyfus GD, Dulguerov F, Marcacci C, Haley SR, Gkouma A, Dommerc C, *et al*. "Respect when you can, resect when you should": A realistic approach to posterior leaflet mitral valve repair. The Journal of Thoracic and Cardiovascular Surgery. 2018; 156: 1856–1866.e3.

[8] El-Eshmawi A, Sun E, Boateng P, Pandis D, Rimsukcharoenchai C, Anyanwu A, *et al*. Lessons from reoperations for mitral stenosis after mitral valve repair. The Journal of Thoracic and Cardiovascular Surgery. 2021; 161: 937–946.

[9] Chan KL, Chen SY, Chan V, Hay K, Mesana T, Lam BK. Functional significance of elevated mitral gradients after repair for degenerative mitral regurgitation. Circulation. Cardiovascular Imaging. 2013; 6: 1041–1047.