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Clinical Investigation

Short-Term Results on Leaflet Mobility in Patients Undergoing Rheumatic Mitral Valve Repair With an Efficient 4-Step Commissuroplasty Technique

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Background: *Mitral valve stenosis (MS) is the primary pathologic feature of rheumatic mitral valve disease, and the complex repair affects its clinical outcome. This study aimed to examine the efficacy of the 4-step commisuroplasty "SCORe" procedure by assessing changes in the mobility of mitral valve leaflets and its clinical effects.*

Methods: *From September 1, 2018, to January 13, 2019, patients with MS who underwent mitral valve repair with the SCORe procedure in the study center were analyzed in this prospective study. Mitral valve structure was assessed by transthoracic echocardiography pre- and postoperatively as well as during follow-up.*

Results: *In total, 60 consecutive patients were examined. In 56 patients (93.3%), mitral valve orifice area (MVOA) was less than 1.5 cm^2, and mean (SD) MVOA for the whole cohort was 1.20 (0.34) cm^2. The mobility of the anterior leaflet was improved (P < .001) during the cardiac cycle postsurgery, but that of the posterior leaflet was not (P = .591). The mean (SD) coaptation length was increased significantly from 6.69 (1.32) mm to 7.92 (1.24) mm (P < .001) postoperatively. Mean (SD) MVOAs increased to 2.24 (0.38) cm^2 postoperatively (P < .001). During the 1-year follow-up, there were no deaths or reoperations. Follow-up echocardiography revealed minor or mild regurgitation in 98.3% of patients.*

Conclusion: *These findings demonstrated that the SCORe procedure can effectively improve the mobility of mitral leaflets and enlarge the valve orifice area in patients with rheumatic MS in China, with minimal complications and promising results.* ***(Tex Heart Inst J. 2022;49(6):e217801)***

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Rheumatic mitral valve disease, a major heart valvular disease in developing countries, is also the most common indication of mitral valve surgery in China.[1,2] An estimated 7.07 million individuals were expected to be diagnosed with rheumatic heart disease in China in 2015.[3] According to the Carpentier classification of mitral valve regurgitation, rheumatic heart disease belongs to type IIIa, which is characterized by pathologic changes mainly caused by limited valve activity, leading to mitral valve opening and closing dysfunction.[4] Mitral valve repair (MVR), especially of the degenerative mitral valve, has substantial advantages over mitral valve replacement, including improved preservation of left ventricular function, lower operative mortality, ameliorated quality of life, and reduced risk factors associated with anticoagulation.[5-7]

In rheumatic mitral valve stenosis, rheumatic mitral valve repair (rMVR) is more technically demanding, with complex repair operation mode for rheumatic diseases, which affects its clinical application.[8,9] Prosthetic valve replacement remains the most commonly applied procedure for rheumatic mitral valve cases in China, with only few patients treated with rMVR.[10] Since 2011, Beijing Anzhen Hospital, Capital Medical University, Beijing, China, has performed rMVR in clinical practice as a premier heart

center in China. At present, the 4-step commissuroplasty "SCORe" (shaving, checking, commissurotomy, and releasing) procedure has become a common surgical procedure for selected patients with rheumatic mitral valve disease at this center, with a repair rate nearing 73% as of December 2019, indicating effective results.[11]

Different from previous studies, this study aimed to examine the efficacy of the SCORe procedure in rheumatic stenosis by focusing on changes in the mobility of mitral valve leaflets and clinical effects. The results suggested that the SCORe procedure is effective in improving the mobility of mitral leaflets and enlarging the valve orifice area in rMVR, with minimal complications and promising results.

Patients and Methods

Patients

From September 1, 2018, to January 13, 2019, all consecutive patients with predominant rheumatic mitral stenosis undergoing MVR with the SCORe procedure in Beijing Anzhen Hospital, Capital Medical University, Beijing, China, were enrolled in this prospective study. In addition to patients with tricuspid valve repair and atrial radiofrequency ablation, those with moderate/severe mitral regurgitation (MR), other operations, and/or previous cardiac surgeries (percutaneous mitral balloon commissurotomy [PMBC]) were excluded. During this period, 77 patients underwent surgery for rheumatic mitral valve stenosis, including 17 who had serious calcification contractures and severe changes in mitral valve morphology. The surgeon performed valve replacement directly in 17 patients, who were also excluded; therefore, 60 patients were evaluated. All patients provided signed informed consent. This study was approved by the ethics review committee of Beijing Anzhen Hospital, Capital Medical University, Beijing, China (No. 20180966x).

Echocardiography Assessment

Perioperative transthoracic echocardiography (TTE) on a Siemens Acuson SC2000 ultrasound machine was performed in all patients, and intraoperative transesophageal echocardiography was carried out to analyze the valve before and after the repair process. The morphology and structure of mitral valves were carefully assessed according to the Wilkins score. Based on 2014 and 2017 American Heart Association/American College of Cardiology guidelines for the management of patients with valvular heart disease,[12] mitral stenosis (MS) was graded as follows: very severe (mitral orifice area [MVOA] ≤1.0 cm^2), severe (MVOA, ≤1.5 cm^2), and progressive (MVOA, ≤2.0 cm^2). Mitral regurgitation was graded as mild (effective regurgitant orifice [ERO] <0.2 cm^2), moderate (ERO, <0.4 cm^2), or severe (ERO, ≥0.4 cm^2). The length of anterior mitral leaflet (L-AML), length of posterior mitral leaflet (L-PML), and coaptation length (CL) were measured from the parasternal long axis view. Leaflet mobility was reflected by the angle between the leaflet and mitral annulus line. A line was drawn at the level of the mitral annulus. Then, 2 lines were drawn connecting the tips of the leaflets and the annulus, and α and β referred to anterior and posterior leaflet angles, respectively. During diastole, α_1 and β_1 were defined as anterior and posterior leaflet angles in diastole, respectively, and α_2 and β_2 were anterior and posterior leaflet angles in systole, respectively (Fig. 1).

Surgical Techniques

The median sternotomy approach and conventional ascending aorta and bicaval cannulation were performed in all patients. The interatrial approach was carried out for mitral valve exposure. The repair techniques were performed in 4 steps in general and mainly based on commissuroplasty (Fig. 2).

Step 1: Shaving. Sutures were made within the annulus for good exposure of the mitral valve. A 4-0 traction suture was made on each commissural leaflet and used to pull the 2 sides of the commissure into the same plane. Then, commissure and leaflet shaving and decalcification were performed to recover the mobility of the commissure.

Step 2: Checking. Two nerve hooks were used for traction, which allows visualization of the distribution of the subvalvular apparatus as well as the natural delineation between the anterior and posterior commissural leaflets.

Step 3: Commissurotomy. An incision was made along the natural commissural line toward about 2 to 3 mm from the annulus. The surgeon monitored the distribution of the chordae tendineae during this process.

Step 4: Releasing. The corresponding adherent chordae or papillary muscle was split in case the leaflets remained retracted or of insufficient MVOA after commissurotomy.

Following the steps above, to complete the operation in the anterior and posterior commissure continuously, the saline test was performed to assess mitral valve competence. An annuloplasty ring was implanted in all patients. Individuals with atrial fibrillation (AF) underwent the Cox-maze IV procedure, and the left atrial (LA) appendage was closed from the inside of the LA simultaneously.

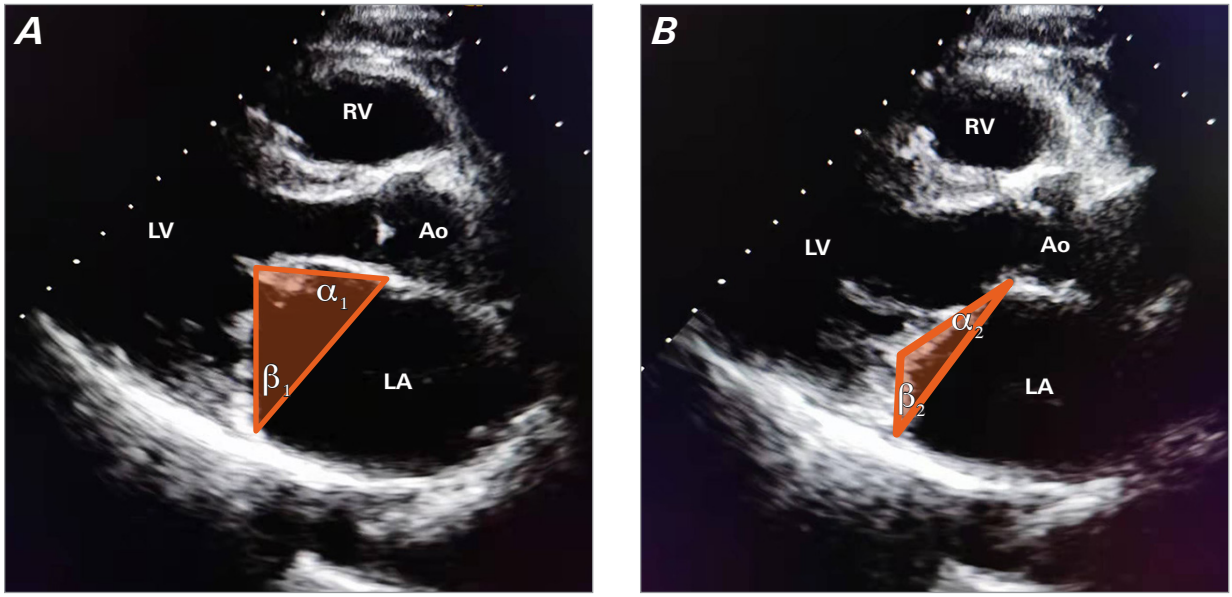

Fig. 1 *Leaflet mobility was determined by drawing a line at the level of the mitral annulus and then drawing lines from the tips of anterior leaflet (α) and the posterior leaflet (β) to the mitral annulus.* ***A****) During diastole, the respective angles were defined as* α_1 *and* β_1 *and* ***B****) during systole as* α_2 *and* β_2.

Ao, aorta; LA, left atrium; LV, left ventricle; RV, right ventricle.

Postoperative Management

All patients routinely received warfarin for anticoagulation for 3 months postoperatively because of annuloplasty ring implantation, with a target international normalized ratio of 2.0 to 2.5, and which was continued in case of persistent AF.

Follow-Up

Follow-up was performed until January 2020 via telephone interview, WeChat, and follow-up website.[13] All patients were asked to return to the study institution for examination by TTE at 3 months, 6 months, and 12 months after surgery. Data were measured and analyzed by the same echocardiography specialist in the study center. Operative mortality was defined as death within 30 postoperative days. Valve-related complications included reoperation, infective endocarditis, and bleeding complications secondary to anticoagulation during follow-up. Other clinical data, including New York Heart Association (NYHA) functional class, were also recorded.

Statistical Analysis

Clinical and echocardiographic variables were analyzed using SPSS Statistics version 22.0 for Windows (IBM Corp). Continuous variables had normal distribution in the Shapiro–Wilk test and were presented as mean (SD). Categorical variables were presented as number or frequency. Variables before and after the procedure were compared by paired Student *t* test for continuous variables, and the Wilcoxon test was used for nonparametric data. $P < .05$ was considered statistically significant.

Results

Baseline Patient Characteristics

A total of 60 patients were analyzed, including 42 (70%) women. The mean (SD) age at surgery was 56.9 (9.9) years, with a range from 28 to 75 years. Exertional dyspnea was the predominant symptom in most patients. A total of 25 (41.7%) patients had NYHA class III or higher. Fifty-six (93.3%) patients had an MVOA below 1.5 cm^2. The mean (SD) Wilkins score was 9.23 (2.56) preoperatively. Atrial fibrillation was present in 46 (76.7%) patients, 4 of whom had LA thrombus. Detailed baseline characteristics are summarized in Table I.

Surgical Outcomes

All patients survived the repair operation. There was no mitral replacement and re-cross-clamp during the operation. The mean (SD) cardiopulmonary bypass time was 110.38 (28.46) minutes, and the mean (SD) aorta cross-clamp time was 82.36 (23.10) minutes. A total of 93.3% of all patients underwent tricuspid valve repair. Commissurotomy was the main technique used in rMVR and was performed in 58 patients (96.7%) on both commissures and in only 2 patients on single anterior commissure. Leaflet shaving on the commissure area was used in 57 individuals (97%), with extra shaving on leaflet body of A2 and P2 in 5 patients. An annuloplasty ring was implanted in all patients. A total of 26 (43.3%) patients had 30-mm rings implanted. Table II summarizes the details of MVR techniques.

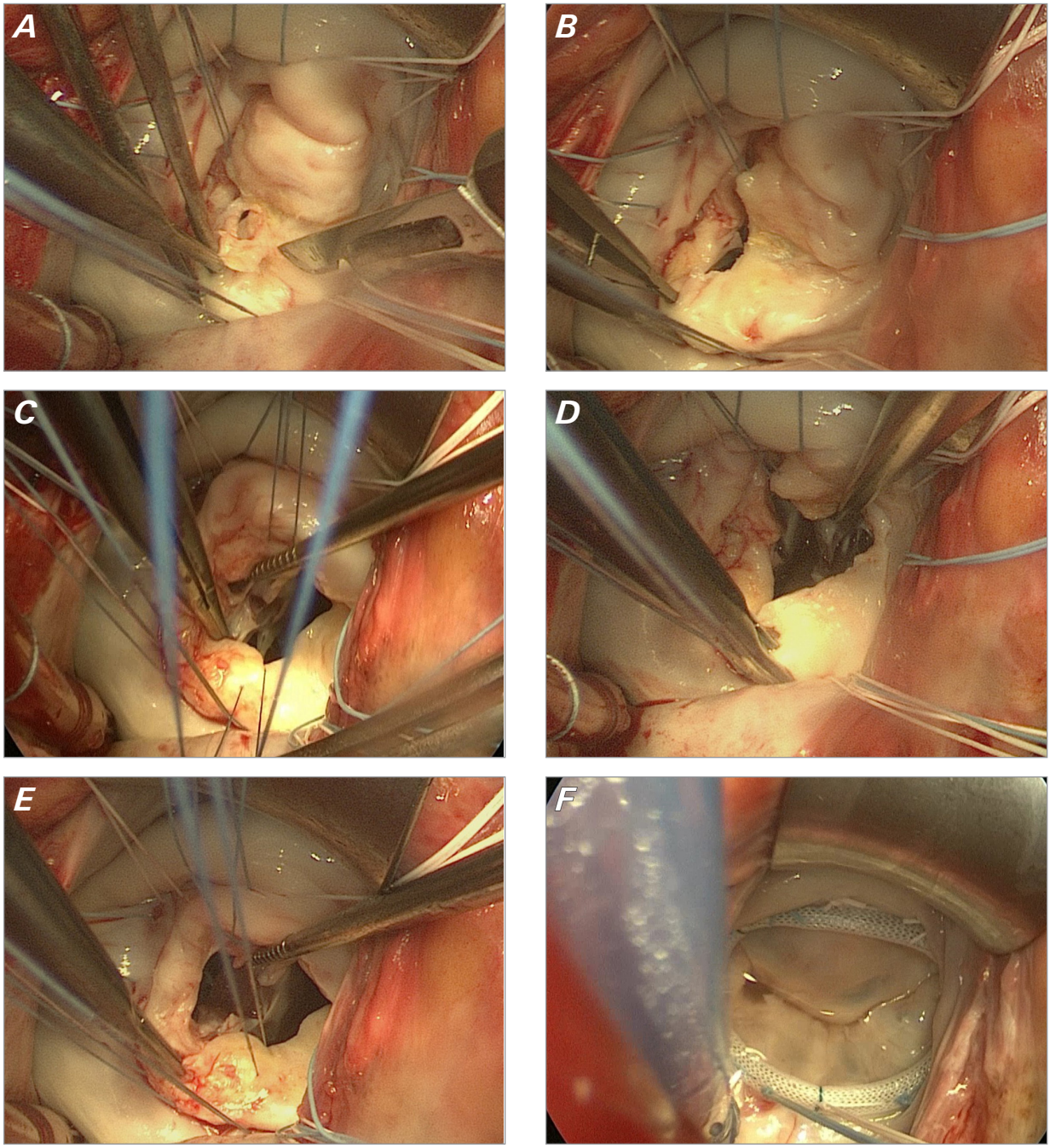

Fig. 2 *The operative technique.* ***A****) The commissure and leaflet are shaved and decalcified to restore mobility and flexibility of the commissural area. The commissural leaflets are kept loose with the use of nerve hooks* ***B****) to ensure the exact natural delineation of the commissure border and* ***C****) to detect the subvalvular apparatus.* ***D****) The incision is extended along the natural commissural line toward the annulus, while distribution of the subvalvular chordae tendineae to the anterior and posterior leaflets is noted.* ***E****) The corresponding adherent chordae or papillary muscle is split in case the leaflets are still retracted. The split extends no more than one-half of the whole papillary muscle.* ***F****) An annuloplasty ring is implanted, and a saline test is performed.*

Echocardiographic Data After the Operation

No moderate or severe MR was detected by TTE in any patient before discharge. Rheumatic MVR caused substantial changes in the morphologic and hemodynamic characteristics of the mitral valve. There were significant changes in MVOA and LA diameter postoperatively. The mean (SD) MVOA increased from 1.20 (0.34) cm^2 to 2.24 (0.38) cm^2 postoperatively ($P < .001$). Meanwhile, the mean (SD) LA diameter decreased significantly from 49.41 (10.89) mm to 45.89 (7.83) mm ($P < .001$). However, no statistically significant differences were found in left ventricular ejection fraction, left ventricular end-diastolic dimension, or left ventricular

TABLE I. Baseline Patient Characteristics

Characteristic	MVR (n = 60)
Age, mean (SD), y	56.9 (9.9)
Female, No. (%)	42 (70.0)
BMI, mean (SD), kg/m^2	24.3 (3.0)
NYHA class, No. (%)	
II	35 (58.3)
III	22 (36.7)
IV	3 (5.0)
MVOA, cm^2	
1.5-2.0	4 (6.7)
1.0-1.4	35 (58.3)
<1.0	21 (35.0)
MR, No. (%)	
None	11 (18.3)
Mild	49 (81.7)
WS, mean (SD)	9.23 (2.56)
Leaflet mobility, mean (SD)	2.79 (0.65)
Subvalvular thickening, mean (SD)	2.26 (1.04)
Valve thickness, mean (SD)	3.15 (0.73)
Valvular calcification, mean (SD)	1.33 (1.03)
Moderate/severe TR, No. (%)	44 (73.3)
AF, No. (%)	46 (76.7)
LAT, No. (%)	4 (6.7)

AF, atrial fibrillation; BMI, body mass index; LAT, left atrial thrombus; MR, mitral regurgitation; MVOA, mitral valve orifice area; MVR, mitral valve repair; NYHA, New York Heart Association; TR, tricuspid regurgitation; WS, Wilkins score

TABLE II. Details of Rheumatic Mitral Valve Repair Techniques

Repair technique	No. (%) of cases
Commissurotomy	60 (100.0)
Anterior/posterior/both	2/0/58
Leaflet shaving	
Only commissural leaflet	52 (86.7)
Commissural + A2/P2 leaflet	5 (8.3)
Subvalvular apparatus releasing	
Chordal splitting	55 (91.7)
Papillary muscle splitting	34 (56.7)
Secondary chordal resection	8 (13.3)
Decalcification	28 (46.7)
Ring annuloplasty	60 (100.0)
Carpentier-Edwards Physio II (Edwards Lifesciences)	36 (60.0)
Sorin Memo 3D (Sorin Biomedica Cardio S.r.L.)	24 (40.0)
Ring size, mm	
30	26 (43.3)
32	24 (40.0)
34	10 (16.7)

end-systolic dimension postoperatively vs preoperative values.

Regarding leaflet parameters, both α_1 and α_2 changed substantially after surgery. In fact, the mean (SD) α_1 increased from 44.53° (9.68°) to 59.87° (7.27°) ($P < .001$), and the mean (SD) α_2 decreased from 25.07° (4.10°) to 16.80° (6.16°) ($P < .001$) after surgery. However, β_1 and β_2 did not have such changes. There were no substantial changes in L-AML or L-PML postoperatively. The mean (SD) CL improved significantly, from 6.69 (1.32) mm to 7.92 (1.24) mm ($P < .001$) after surgery (Table III).

Follow-Up Findings

All patients completed the 1-year follow-up visits through January 2020. Of these, 58 patients were evaluated by TTE at 3 months postoperatively. Further, 51 patients completed echocardiography evaluation in the study center throughout the follow-up period, while 9 were examined at their local hospitals.

No deaths, reoperations, or severe complications occurred during follow-up. Three patients were readmitted for transthoracic synchronized defibrillation therapy because of AF after discharge. Only 1 patient showed moderate or severe MR (ERO, 0.3 cm^2 near the posterior commissure) at 6 months after surgery. Because of the absence of obvious clinical symptoms, the patients were followed up by medical therapy. Echocardiography follow-up data are summarized in Table IV.

Discussion

This prospective study demonstrated that the SCORe procedure is effective in improving the mobility of mitral leaflets and MVOA in rMVR, with minimal complications and promising results. Although rMVR remains controversial, many studies have confirmed its feasibility and effectiveness as well as advantages in survival, complications, and other aspects, compared with mitral valve replacement.[5,8,14] However, in most reports about rMVR, mitral insufficiency is considered the predominant lesion.[15-18] In contrast, this study focused on patients with MS.

TABLE III. Echocardiographic Data

	Preoperation, mean (SD)	At discharge, mean (SD)	*P* value[a]
LA, mm	49.41 (10.89)	45.89 (7.83)	<.001
LVEDD, mm	45.22 (3.65)	44.69 (3.80)	.147
LVESD, mm	29.56 (3.82)	28.78 (3.57)	.280
LVEF, %	62.39 (7.19)	62.53 (6.10)	.920
MVOA, cm^2	1.20 (0.34)	2.24 (0.38)	<.001
E_{max}, cm/s	195.21 (41.45)	159.74 (41.51)	<.001
α_1, °	44.53 (9.68)	59.87 (7.27)	<.001
α_2, °	25.07 (4.10)	16.80 (6.16)	<.001
β_1, °	74.00 (17.12)	76.93 (11.55)	.591
β_2, °	53.10 (13.95)	48.80 (23.66)	.342
α_1-α_2, °	19.47 (8.87)	43.07 (9.37)	<.001
β_1-β_2, °	21.02 (9.87)	28.13 (24.43)	.325
L-AML, mm	26.50 (3.68)	26.89 (4.18)	.165
L-PML, mm	12.23 (3.10)	12.35 (2.92)	.404
CL, mm	6.69 (1.32)	7.92 (1.24)	<.001

α_1, anterior leaflet angle in diastole; α_2, anterior leaflet angle in systole; β_1, posterior leaflet angle in diastole; β_2, posterior leaflet angle in systole; CL, coaptation length; E_{max}, transmitral E peak velocity; LA, left atrium; L-AML, length of anterior valve leaflet; L-PML, length of posterior valve leaflet; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; LVEF, left ventricular ejection fraction; MVOA, mitral valve orifice area.

[a] $P < .05$ was considered statistically significant.

Thickening, fibrosis, and calcification are factors affecting the activity of the leaflet; therefore, leaflet thinning is an important technique in rMVR.[19] Commissural fusion in a rheumatic mitral valve is the most important reason for decreased MVOA and valve insufficiency.[10] Therefore, commissurotomy is a widely used technique for alleviating valve stenosis in rMVR.[17,20,21] In the past, for the correction of MS, simple commissurotomy was performed to improve the mitral orifice and to recover the mobility and coaptation by correcting the length and thickness of leaflets. However, correction of commissural leaflet areas has been neglected. Although simple commissurotomy indeed increases the orifice area, it does not improve the activity of commissural leaflets that may cause regurgitation in the commissure area because of poor coaptation. Moreover, the thickened and fused leaflets affect the identification of natural commissure by the surgeon, which may affect the result of commissurotomy. If an incision is too small, the mitral valve cannot fully open, whereas too large an incision may destroy the commissural leaflets and cause regurgitation at the commissural area in systole. Commissural leaflet shaving and decalcification not only help improve the softness of the commissure; they also reveal the boundary of fused anterior, posterior, and commissural leaflets, which is a good indicator for commissurotomy. After this commissure shaving, commissurotomy effectively improves the opening of the mitral valve and the mobility of leaflets. Therefore, leaflet shaving and decalcification were performed as the first procedural step in the study center.

In this study, 57 patients (95%) underwent commissure leaflet shaving, and extra peeling of leaflet body was performed in only 5 individuals. The rate of decalcification was approximately 46.7%, and no obvious calcified annulus was found. To reduce the limitation of leaflet mobility, calcification in any position on the leaflet should be removed to the extent possible. The results showed that valve opening and movement were improved after repair, mean (SD) α_1 increased from 44.53° (9.68°) preoperatively to 59.87° (7.27°) ($P < .001$), whereas the mean (SD) β_1 increased from 74.00° (17.12°) preoperatively to 76.93° (11.55°) postoperatively ($P = .591$). In addition, as in rheumatic mitral valve disease, thickening, fibrosis, and calcification are often more serious on the posterior leaflet body.[10] Here, the improvement in the mobility of the anterior leaflet was more substantial than that of the posterior leaflet postoperatively (Fig. 3). However, the increased MVOA was unaffected by the posterior leaflet. These findings suggest that it is very important to recover the mobility of the anterior mitral leaflet in rMVR.

A shortened leaflet affects its mobility. Gupta et al[22] suggested L-AML as a predictor of rMVR, with a value of 26 mm or more predicting reparability. In that study, a pericardial patch was used to increase the area of the anterior leaflet to increase its mobility and CL. Although many studies have confirmed good out-

TABLE IV. Echocardiographic Data During Follow-Up[a]

	At discharge	3 mo postoperatively	6 mo postoperatively	12 mo postoperatively
Echo parameter (n = 60)				
LA, mean (SD), mm	45.78 (7.59)	44.46 (7.91)	44.54 (8.61)	45.08 (8.32)
LVEDD, mean (SD), mm	44.69 (3.80)	44.74 (4.29)	45.08 (3.88)	45.87 (3.82)
LVESD, mean (SD), mm	28.78 (3.57)	28.83 (3.45)	29.08 (3.78)	28.56 (3.86)
LVEF, mean (SD), %	62.53 (6.10)	62.17 (4.54)	63.03 (3.69)	63.78 (3.03)
MVOA, mean (SD), cm^2	2.24 (0.38)	2.39 (0.36)	2.27 (0.40)	2.25 (0.35)
E_{max}, mean (SD), cm/s	159.74 (41.51)	153.38 (37.39)	154.74 (40.78)	158.56 (35.26)
Moderate/severe MR, No. (%)	0	0	1 (1.7)	1 (1.7)
Leaflet parameter	n = 60	n = 58	n = 51	n = 51
α_1, mean (SD), °	59.87 (7.27)	58.80 (7.10)	57.87 (4.92)	59.07 (5.75)
α_2, mean (SD), °	16.80 (6.16)	17.67 (6.38)	18.20 (6.02)	17.20 (7.49)
β_1, mean (SD), °	76.93 (11.55)	77.20 (10.46)	76.67 (8.58)	76.80 (6.72)
β_2, mean (SD), °	48.80 (23.66)	49.27 (22.63)	48.20 (22.55)	47.13 (21.45)
L-AML, mean (SD), mm	26.89 (4.18)	26.61 (4.05)	27.33 (4.42)	26.74 (4.23)
L-PML, mean (SD), mm	12.35 (2.92)	12.56 (2.82)	12.15 (2.98)	12.79 (3.25)
CL, mean (SD) mm	7.92 (1.24)	7.76 (1.05)	7.84 (1.36)	8.02 (1.22)

α_1, anterior leaflet angle in diastole; α_2, anterior leaflet angle in systole; β_1, posterior leaflet angle in diastole; β_2, posterior leaflet angle in systole; CL, coaptation length; E_{max}, transmitral E peak velocity; LA, left atrium; L-AML, length of anterior valve leaflet; L-PML, length of posterior valve leaflet; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; MR, mitral regurgitation; MVOA, mitral valve orifice area

[a] $P < .05$ was considered statistically significant. The differences among groups in echocardiographic measurements in patients at discharge and at 3, 6, and 12 months were not statistically significant ($P > .05$).

comes for autologous pericardial patch in rMVR,[20,23,24] the procedure is relatively complex, as the patch size is often difficult to determine and the subvalvular structure is usually destroyed. In addition, Dion et al[25] used a pericardial patch on posterior mitral leaflet for MS repair and achieved good clinical results. However, this method requires more precision in patch creation to avoid systolic anterior motion. In contrast, the repair method in this study did not affect the length of mitral leaflets. The mean (SD) L-AML value was 26.50 (3.68) mm (range, 20-33 mm), and 48% of the assessed patients had a length less than 26 mm. This did not affect repair outcome. Further, the anterior leaflet area can be obtained indirectly by measuring the size of the artificial ring. In the present study, 83.3% of patients had rings implanted with a diameter of 30 mm or 32 mm. Although the ring size was smaller than that commonly used in degenerative MVR, the results of this study indicated that most patients with rheumatic MS had sufficient leaflet body area to meet the need for coaptation.

Chordal thickening and fusion are the most common subvalvular pathology in rMVR, which restricts the mitral valve in the cardiac cycle and decreases coaptation. According to previous studies, the rate of subvalvular release might be lower in cases of rheumatic MR.[18,26] Unlike MR, in which valve prolapse or enlarged annulus results in a loss of coaptation, patients with pure MS do not have coaptation problems preoperatively. However, with mitral orifice opening and increased volume of the left ventricle after surgery, leaflet movement will be restricted and cause regurgitation. Therefore, subvalvular apparatus release is beneficial to render the valve more mobile and freer to move. Chotivatanapong et al[27] assessed 221 rMVR procedures; of these, secondary chordal resection and papillary muscle splitting accounted for 54.7% and 49.8%, respectively.

In this study, 35% of patients underwent chordae splitting only, and 56% required splitting of both the chordae tendineae and papillary muscles. The mean (SD) CL was significantly improved postoperatively (7.92 [1.24] mm vs 6.69 [1.32] mm; $P < .001$) and was maintained at 8.02 (1.22) mm 1 year after surgery. However, whether this increase was affected by the use of annuloplasty rings is unknown. In addition, α_2 and β_2 decreased postoperatively, which indicated that with the relief of subvalvular restriction, the movement of leaflets was improved in systole. Although chordae transfer and artificial chordae are also available and effective in rMVR, these options are not commonly applied in the center in the present study.

The use of an annuloplasty ring has become a standard technique in MVR, especially for degenerative MR, which is often accompanied by annular dilatation.

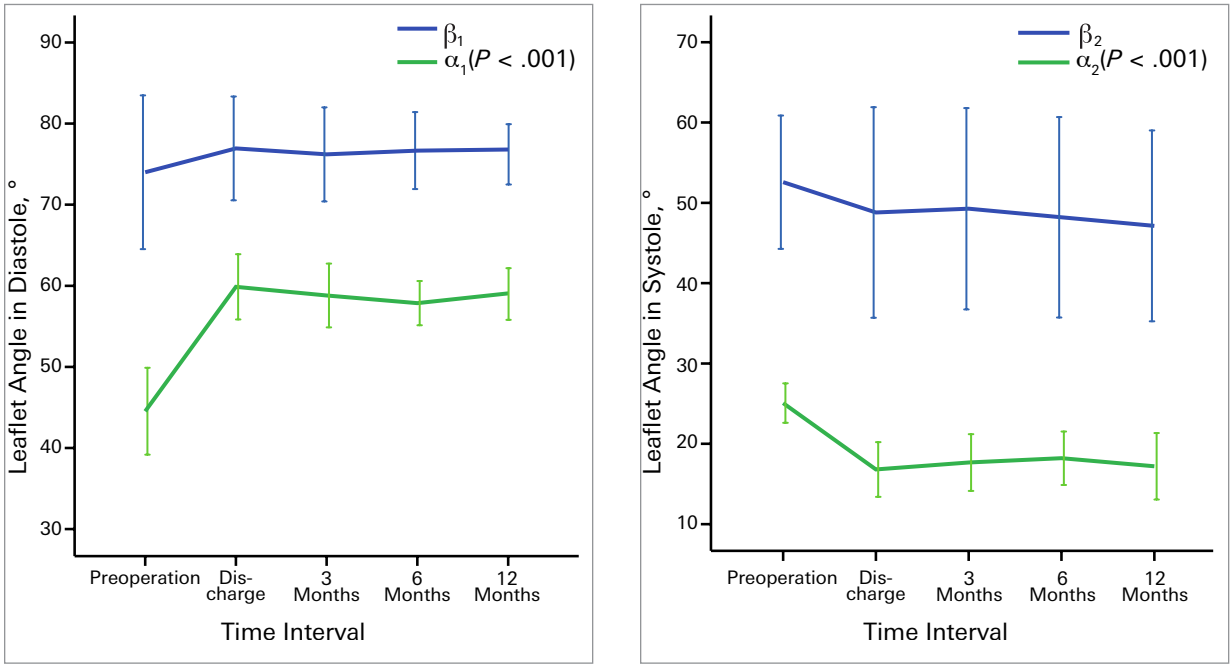

Fig. 3 *Graphs show the effect of surgery on leaflet angles.* ***A****) During diastole, the anterior leaflet angle (α1) was substantially increased and stabilized postoperatively, indicating improved anterior leaflet opening. The posterior leaflet angle (β_1) was not substantially changed.* ***B****) During systole, the anterior leaflet angle (α_2) was substantially decreased and stabilized postoperatively, indicating improved anterior leaflet swelling, while the posterior leaflet angle (β_2) was not substantially changed.* P < .05 *was considered statistically significant.*

Annuloplasty using a prosthetic ring in degenerative MR can effectively improve short-term and long-term repair efficacy. However, there is still some controversy about the need for prosthetic rings in patients with rheumatic mitral valve disease. Li et al[28] compared the annular structure between rheumatic and degenerative mitral valve diseases and found that the annulus structure in rheumatic mitral valve also changes, losing its saddle shape. Bernal et al[29] reported that an artificial ring could also substantially reduce the reoperation rate in patients with rheumatic mitral dysfunction. Therefore, a 3-dimensional complete annuloplasty ring is routinely implanted in all patients, even those with rheumatic MS. Previous findings[21] suggested implanting an oversized ring in rMVR to prevent stenosis and systolic anterior motion. However, selection of annuloplasty ring size based on anterior leaflet length could be just enough and achieve good results.

Enlarged LA affects left ventricular function and sinus rhythm maintenance after radiofrequency ablation.[30] After correction of valve orifice stenosis in LA dilatation caused by MS, LA volume can be effectively reduced to improve ventricular function, decrease the risk of thrombosis, and improve the outcome of radiofrequency ablation on AF, which may substantially increase the odds of mitral dysfunction and adverse outcomes. Left atrial plication was suggested for an LA diameter exceeding 50 mm on preoperative echocardiography.[8] In the current patients, LA plication was not applied. Although the patients had LA dilatation (mean [SD], 49.41 [10.89] mm) at baseline, the mean (SD) LA size was substantially reduced to 45.08 (8.32) mm at 12 months after surgery. Internal obliteration of LA appendage was performed in patients with AF to decrease the risk of thrombosis.

Percutaneous mitral balloon commissurotomy is considered the first choice for selected suitable rheumatic MS by guidelines for the management of valvular heart disease in Europe and the United States.[12,31] Because of regional and pathologic differences, as well as the development of valvular surgery, PMBC is used less frequently in China. Although PMBC and surgical repair have not been fully compared, commissuroplasty has certain advantages over PMBC, as follows.

1. Release of subvalvular apparatus, which may enhance the effect of commissurotomy, cannot be performed in PMBC.
2. Commissuroplasty can accurately separate the fused commissure along the normal anatomic position, whereas PMBC splits the weakest area of the leaflets with high risk of MR.
3. Applying an annuloplasty ring can increase CL and stabilize the annular structure, which cannot be achieved by PMBC.

The present study examined the short-term results of all patients. Clinical outcomes were promising during the follow-up visits. MVOA was stable in patients 12 months postoperatively (Fig. 4). Only 1 patient showed

moderate MR (1.67%) but without clinical symptoms during follow-up. In a study by Kim,[32] 61 patients showed severe valve dysfunction postoperatively, within a mean (SD) follow-up of 71.9 (41.0) months, with 51 (83.6%) MR cases, suggesting MR as the main cause of long-term mitral dysfunction. According to a study by Kim et al,[33] most reoperations because of recurrent MR occur within the first 6 months after surgery, with the reoperation rate decreasing afterward. The above-described findings indicate that the current patients may also experience satisfactory long-term results.

Although rMVR provides multiple advantages, not all patients with rheumatic mitral disease are eligible for repair in current clinical practice. In addition, success in this procedure depends on the severity of valvular calcification as well as the surgeon's technical skills. The primary limitation of the study is that it was a pre/post study with no control group of patients with rheumatic MS who underwent other surgeries. Furthermore, this was a single-center study focusing on a patient population predominantly with MS, instead of all types of rheumatic mitral lesions. Follow-up was also relatively short in this study. Although the early outcomes can reflect changes in mitral leaflet mobility and subsequent efficacy after rMVR to some degree, long-term follow-up is still needed for a comprehensive evaluation, particularly valve leaflet activity assessment. Finally, the sample size was relatively small, and larger studies are required to improve the generalizability of these findings.

In all, repair surgery for rheumatic MS is rarely carried out because the related surgical methods are diverse and inconsistent, making it difficult to master. The SCORe surgery provides a new idea for repairing rheumatic MS. Previous studies have also confirmed the effectiveness of this method. However, studies examining the improvement of valve leaflet activity are lacking. Therefore, this study aimed to assess the activity of the valve leaflet. Long-term follow-up of valve leaflet activity still deserves further investigation.

Conclusion

In select patients with rheumatism in China, commissuroplasty effectively improves leaflet mobility, thereby increasing MVOA and CL while preserving the original mitral leaflet length and the subvalvular apparatus. These short-term results need to be further validated with large sample sizes and prospective studies.

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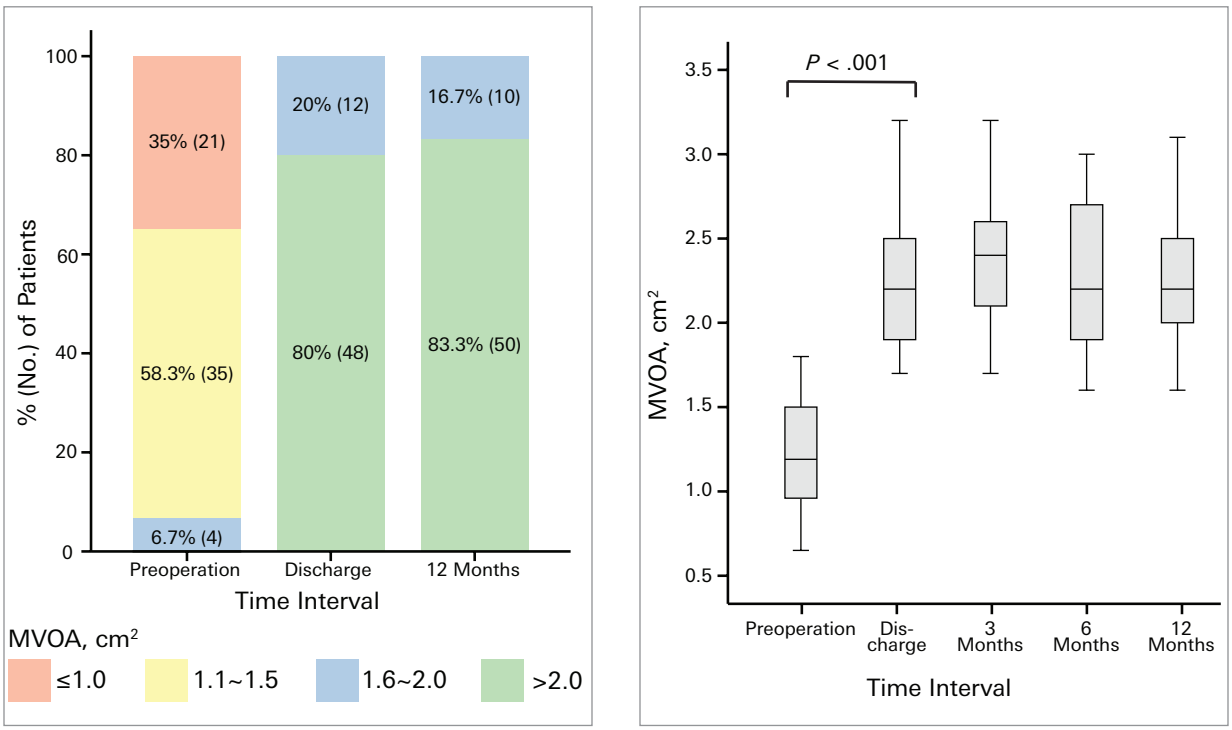

Fig. 4 ***A****) After operation, the MVOA was greater than 2.0 cm² in most patients, representing a significant improvement compared with the preoperative measurements (*P = .001*), and the improvement was maintained at 1 year.* ***B****) The box plot shows a substantially improvement in MVOA after surgery.* P < .05 *was considered statistically significant.*

MVOA, mitral valve orifice area

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Ethical Statement:

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