

# Features of rheumatic mitral valves and a grading system to identify suitable repair cases in China

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**Background:** We aimed to assess the pathological characteristics of rheumatic mitral valve disease in Chinese patients and formulate a pathological grading system to identify cases suitable for rheumatic mitral valve repair (rMVP).

**Methods:** Nearly 5 years of follow-up data on patients who underwent rMVP were analysed. A Kaplan-Meier survival curve for freedom from reoperation and valve failure was constructed. A pathological grading system of rheumatic mitral valve lesions (PGSRMVL) was developed based on the pathological characteristics of rheumatic mitral valve disease and tested by receiver operating characteristics (ROCs) curve analysis. Predictors of endpoints for rheumatic repair were analysed.

**Results:** From January 2012 to June 2016, 179 patients underwent rMVP in our centre. The mean follow-up duration was 24±14 months. A left atrial anterior and posterior diameter >60 mm was an independent predictor for the 16 endpoints [hazard ratio (HR) =3.884, P=0.029]. Between 2015 and 2016, 126 consecutive pathological characteristics of rheumatic mitral valve were evaluated (61 and 65 repair and replacement cases, respectively). The ROCs area under the curve was 0.891 for the correlation between the pathological score and successful repair (cut-off point, 17.5; sensitivity, 78%; specificity, 85.2%). Seven lesions had higher ratios in the replacement group than the repair group. Commissural fusion/calcification and main chordae tendineae fusion/calcification were the most common severe pathological lesions.

**Conclusions:** The main pathological characteristics of rheumatic mitral valve disease in Chinese patients are commissure and sub-valvular apparatus lesions. Most patients can be appropriately treated via commissurotomy and leaflet thinning. Severe calcification of the commissure and sub-valvular apparatus can considerably decrease the odds of a successful repair. The median follow-up results of rheumatic mitral repair are considered satisfactory for the pathological characteristics in Chinese patients.

**Keywords:** Rheumatic; pathological; repair; Chinese

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## Introduction

Rheumatic heart disease affects approximately 2 million adult Chinese patients and has a prevalence of 2% (1). According to statistics from a database from Anzhen Hospital Cardiac Valve Centre, among 7,952 patients who underwent mitral

valve operation, 3,221 (40.5%) suffered from rheumatic disease in the last 20 years. Among most Chinese surgeons, the procedure of choice to treat rheumatic heart disease is mitral valve replacement (MVR) (2). The feasibility and durability of rheumatic mitral valve repair (rMVP), another

procedure to treat rheumatic heart disease, were confirmed using the mid-to-long-term follow-up results of foreign studies (3-5). Nevertheless, there are many discrepancies between the pathological characteristics described in those studies and those described for Chinese patients. For example, the preoperative pathology was regurgitation in most cases, and the ratio of stenosis and mixed lesion was low (3,6,7). The proportion of women was low (3), and the majority of patients were young and middle-aged (8,9). Meanwhile, the pathological characteristics of rheumatic mitral valve disease in Chinese patients have not been thoroughly evaluated.

Rheumatic heart disease is still the most common cause of valve disease in China. Therefore, we aimed to describe and analyse the pathological characteristics of rheumatic mitral valve disease in Chinese patients and to formulate a pathological grading system to clearly identify cases that are suitable to undergo rMVP under the condition of current surgical techniques of mitral repair.

## Methods

### *Patient data and endpoints*

Data from patients who underwent rMVP between January 2012 and June 2016 were collected. The main endpoints were re-operation or death in the follow-up period. The secondary endpoint was more than moderate mitral stenosis or regurgitation in the follow-up period. Data from consecutive patients who underwent mitral valve repair (MVP) or MVR for rheumatic disease between September 2015 and June 2016 were collected to evaluate the pathological characteristics of rheumatic mitral valve disease. Based on these data, a pathological grading system of rheumatic mitral valve lesion (PGSRMVL) was developed (Table 1). The system contains the following three main parts: the leaflet, commissure, and sub-valvular apparatus. Each grade was defined in detail. Based on the clinical experience of our team, we chose to classify it this way. All evaluation results were based on visual observation.

All study participants provided informed consent. The study design was approved by the ethics review board of the Capital Medical University affiliated Beijing Anzhen Hospital (No. 857-3).

### *Statistical analysis*

Continuous variables are expressed as means  $\pm$  standard

deviations. Discrete variables are described as percentages. Univariate analysis of continuous variables was carried out with Student's *t*-test. Univariate analysis of categorical data was carried out with the  $\chi^2$  or Fisher's exact tests. Analysis of freedom from reoperation and valve failure was performed with the Kaplan-Meier survival curve. The PGSRMVL was tested using receiver operating characteristics (ROC) curve analysis. Cox regression analyses were used to determine the risk factors for the endpoints. SPSS version 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

## Results

From January 2012 to June 2016, 179 patients underwent mitral repair for rheumatic disease in Anzhen Hospital Cardiac Valve Centre. The mean age was  $52.08 \pm 11.89$  years. The percentage of female patients was 74.30%. Preoperatively, persistent atrial fibrillation accounted for 55.87% of cases. Among all 179 rMVP cases, there were 12 cases of repair failure during the operation and 167 cases of successful repair with an intraoperative repair rate of 84.77% (Table 2). Among all surgical techniques, commissurotomy and leaflet thinning accounted for the highest percentage at 90.50% and 70.39%, respectively. The percentages of other techniques were not more than 15% (Table 3).

Data regarding follow-up were obtained until December 2016 and collected during visits to the outpatient clinic or by telephone interviews. The data were 100% complete. The mean follow-up period was  $24 \pm 14$  [6-59] months. In the follow-up period, the main endpoints occurred in 5 patients, including 1 patient who died from intracranial haemorrhage at 1 month after the operation and 4 patients who underwent re-operation (infective endocarditis occurred in 2 patients, and regurgitation occurred in the other 2 patients). The secondary endpoint occurred in 14 patients. Regurgitation occurred in 12 patients among whom 2 required re-operation. Moderate stenosis occurred in 2 patients.

For all 179 cases, the early postoperative echocardiographic indexes (mitral valve orifice area, mitral valve orifice area/body surface area, E-wave, etc.) of the MVP group improved notably compared with the preoperative values. The echocardiographic indexes at 6 months or more than 9 months after the operation were not remarkably different (Table 4). The percentage of freedom from re-operation and valve failure with 5 years in the follow-up period was  $96.4\% \pm 1.8\%$  and  $88.2\% \pm 2.9\%$ , respectively. The majority of endpoints occurred within 1 year after the operation (Figure 1).

**Table 1** The pathological grading system of rheumatic mitral valve lesions

Pathological characteristic	Definition	Score
Leaflet thickening		
Mild	Thickening is confined to the leaflet margins. Thickened leaflet area less than 1/3. Leaflet mid portions and base portions have normal mobility	1
Moderate	Half of the leaflet area is thickened and stiff. Other portions have normal mobility	2
Severe	All or most leaflet portions are thickened and stiff	3
Leaflet calcification		
Mild	The leaflet surface has calcified spots, but the calcification does not reach the full thickness of the leaflet	2
Moderate	Local and single calcification with a diameter less than 1 cm	4
Severe	The full thickness of the leaflet is calcified with a diameter more than 1 cm, or more than 1/3 of the leaflet area is calcified	6
Leaflet contracture		
Mild	The anterior valve height is less than 2.5 cm. The posterior valve height is less than 1.5 cm	1
Severe	The anterior valve height is less than 2 cm. The posterior valve height is less than 1 cm	2
Chordae tendineae thickening		
Mild	Only part of the major chordae tendineae is thickened. Thickening is confined to the joint between the leaflet and chordae tendineae	1
Moderate	Less than half of the major chordae tendineae is thickened	2
Severe	All or most of the major chordae tendineae are thickened and reach the papillary muscles	3
Chordae tendineae fusion		
Mild	Less than 3 chordae tendineae fuse	2
Severe	More than 3 chordae tendineae fuse	4
Chordae tendineae calcification		
Mild	The end of a single or multiple chordae tendineae is calcified, but do not fuse	2
Severe	Multiple chordae tendineae are fused and calcified. The shape is like a ball	4
Chordae tendineae shortening		
Mild	The structures of papillary muscles, chordae tendineae, and margins of leaflets are clearly distinguished. The length of the major chordae tendineae is more than 0.5 cm	2
Severe	The structures of papillary muscles, chordae tendineae, and margins of leaflets are not distinguished. The length of the major chordae tendineae is less than 0.5 cm, or the leaflet is almost directly connected with the papillary muscle	4
Commissural fusion		
Mild	The commissural fusion length is less than 1 cm	1
Moderate	The commissural fusion length is between 1 and 2 cm	2
Severe	The commissural fusion length is more than 2 cm	3
Commissural calcification		
Mild	The commissural calcification scope is less than 1/2. The whole commissure still has partial mobility	2
Severe	The whole commissure is calcified and fixed, losing mobility	4

**Table 2** Perioperative characteristics of all rMVP cases (179 cases)

Index	MVP (%)	F-MVP (%)	All rMVP cases (%)
Cases	167 (intraoperative repair rate =84.77%)	12	179
Sex, female	126 (75.45)	7 (58.33)	133 (74.30)
Age (years)	51.75±11.61	56.67±15.22	52.08±11.89
BSA (m <sup>2</sup> )	1.79±0.17	1.73±0.19	1.79±0.17
Persistent AF	92 (55.10)	8 (66.67)	100 (55.87)
EuroScore II	0.014253±0.011211	0.021298±0.010575	0.0147035±0.0112756
TVP	57 (93.45)	13 (86.67)	119 (94.44)
RFA	41 (67.21)	11 (73.33)	84 (66.67)
AVR/AVP	11/9 (32.79)	5/1 (40)	25/14 (30.95)
LATH	4 (6.56)	2 (13.33)	8 (6.35)
Stenosis	60 (35.93)	2 (16.67)	62 (34.64)
Regurgitation	28 (16.77)	2 (16.67)	30 (16.76)
Mixed lesion	79 (47.31)	8 (66.67)	87 (48.60)
Size of ring	31.12±1.51, 1 case, no ring	30.40±2.61, 5 cases, applied rings	
Male size	31.68±1.49		
Female size	30.93±1.48, 1 case, no ring		
Edward 5200	139 (83.23)	4	
Sorin 3D	17 (10.18)	1	
Medtronic CG	10 (5.99)	0	

Data are presented as n, n (%), or mean ± SD. AF, atrial fibrillation; AVR/AVP, aortic valve replacement/repair; BSA, body surface area; F-MVP, repair failure during the operation; LATH, left atrial thrombus; mixed lesion, stenosis + regurgitation; MVP, successful mitral valve repair; RFA, radiofrequency ablation; rMVP, rheumatic mitral valve repair; TVP, tricuspid valve repair.

Univariate and multivariate Cox regression analyses were used to determine the risk factors of 167 patients who underwent MVP for re-operation and valve failure between January 2012 and June 2016. The preoperative left atrial anterior and posterior diameter (LAAPD) >60 mm [hazard ratio (HR) =3.884, P=0.029] was a significant independent predictor (*Table 5*).

Between September 2015 and June 2016, 126 consecutive rheumatic mitral valve operations were performed. The number of patients with successful repair and replacement operations was 61 and 65, respectively. The percentage of rMVP cases in our centre was 48.41%. The PGSRMVL was used to analyse the pathological characteristics of rheumatic mitral valve for these 126 cases in our centre. The average score of the 126 cases was 17.28±9.8. The most frequent pathological characteristics were anterior commissural fusion (98.41%), anterior leaflet thickening

(95.25%), posterior leaflet thickening (93.65%), posterior commissural fusion (93.65%), and sub-valvular chordae tendineae thickening (76%). The frequencies of severe pathological lesions were as follows: chordae tendineae fusion (45.95%), anterior commissural fusion (41.13%)/calcification (35.42%), chordae tendineae calcification (39.39%), posterior commissural fusion (32.20%)/calcification (36.36%), posterior leaflet thickening (21.19%), and anterior leaflet thickening (10.83%) (*Figure 2A*).

There were no preoperative plans to repair 15 cases and MVR was directly performed, between September 2015 and June 2016. Therefore, 111 cases were analysed. The ROC curve analysis of PGSRMVL for judgment on whether rMVP would be successful showed an ROC area under the curve of 0.891 (cut-off point, 17.5; sensitivity, 78%; specificity, 85.2%) (*Figure 2B*). The number of patients with a PGSRMVL score <17.5 was 75 (59.52%). All pathological

lesions were analysed separately in comparing the MVR group and MVP group. Seven lesions had obviously higher ratios in the MVR group than MVP group. Their P values were less than 0.01 (Table 6). The different number of patient's lesions can lead to different successful repair ratios. If there was no specific pathological lesion present, the repair rate was 78%. If only one lesion was present, the repair rate was nearly 47%. However, if more than one lesion was present, no repair was accomplished (Table 7).

**Table 3** Surgical techniques for mitral valve repair (179 cases)

Repair techniques	Cases	Percentage (%)
Commissurotomy	162	90.50
Leaflet thinning	126	70.39
Papillary muscle splitting	25	13.97
Edge-to-edge	19	10.61
Chordal replacement	14	7.82
Secondary chordal resection	10	5.59
Posterior leaflet plication	4	2.23
Chordal transfer	3	1.68
Posterior leaflet augmentation	1	0.56

**Table 4** Follow-up data of rMVP cases (167 cases)

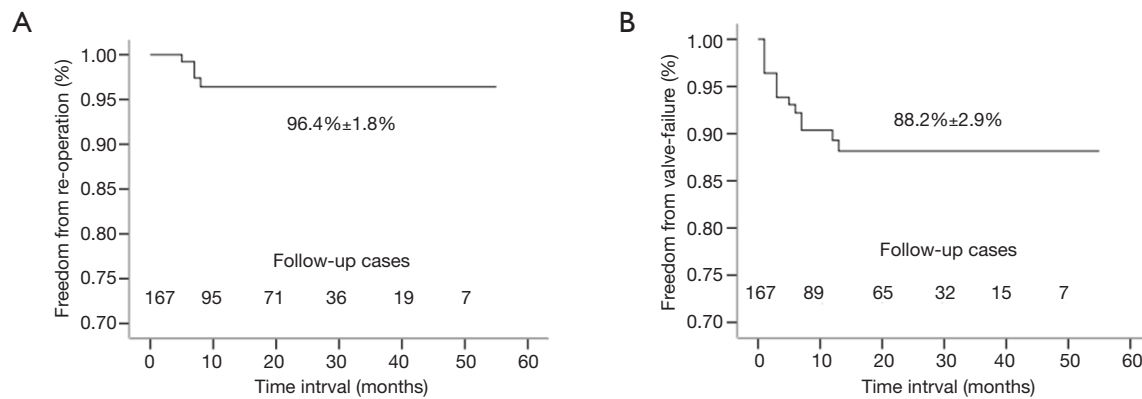
Follow-up indexes	Pre-operation	1 month after the operation	4–6 months after the operation	More than 9 months after the operation
MVOA (cm <sup>2</sup> )	1.45±0.58	2.33±0.48	2.24±0.39	2.22±0.36
MVOA/BSA	0.82±0.31	1.29±0.30	1.26±0.25	1.25±0.23
E-wave (cm/s)	186.62±53.21	158.48±35.08	159.70±38.64	157.98±38.99
MVOA (more than moderate stenosis)	40 cases, 23.95% (MVOA ≤1.0 cm <sup>2</sup> )	1 case, 0.60%	2 cases, 1.20% (newly added 1 case)	2 cases, 1.20%
MRA (more than moderate regurgitation)	48 cases, 28.74% (MRA ≥8.0 cm <sup>2</sup> )	5 cases, 2.99%	11 cases, 2.99% (newly added 6 cases)	10 cases, 5.99% (newly added 1 case)
Re-operation			3 cases (2 cases for MI, 1 case for IE)	1 case for IE
Death		1 case		
All follow-up endpoint events				17 cases, 10.18%

Data are presented as mean ± SD unless otherwise specified. The follow-up endpoint events were death, re-operation, and valve failure. One patient died at 1 month after the operation. During the follow-up period, there were 12, 2, 2, and 4 MI, MS, IE, and re-operation cases, respectively. BSA, body surface area; IE, infective endocarditis; MI, mitral insufficiency; MRA, mitral regurgitation area; MS, mitral stenosis; MVOA, mitral valve orifice area; rMVP, rheumatic mitral valve repair.

## Discussion

Rheumatic heart disease is the most common cause of valve disease in the developing nations (10,11). Chronic inflammation during the rheumatic process may cause narrowing of the valves resulting in decreased blood flow through the heart or leakage of the valves causing blood to flow in the wrong direction. This may eventually lead to arrhythmias such as atrial fibrillation, or heart failure, where the heart is unable to pump enough blood to meet the body's needs (12). Considering its many advantages such as subvalvular apparatus preservation, protection of left ventricular systolic function (13,14), and avoiding risks of thromboembolism and bleeding resulting from warfarin (15,16), MVP has been acknowledged to be superior to replacement (15,17-19). Several cardiac centres in Asian countries have performed rMVP for decades (20), and have gained a considerable amount of experience (3,4). Because of the complexity and durability of rMVP, the majority Chinese surgeons may choose MVR. However, in recent decades, the exploration of surgical techniques for rMVP has increased in our centre each year.

According to the PGSRMVL used in this study, the most common pathological characteristics of rheumatic mitral valve disease were leaflet thickening, commissural fusion, and sub-valvular chordae tendineae thickening.

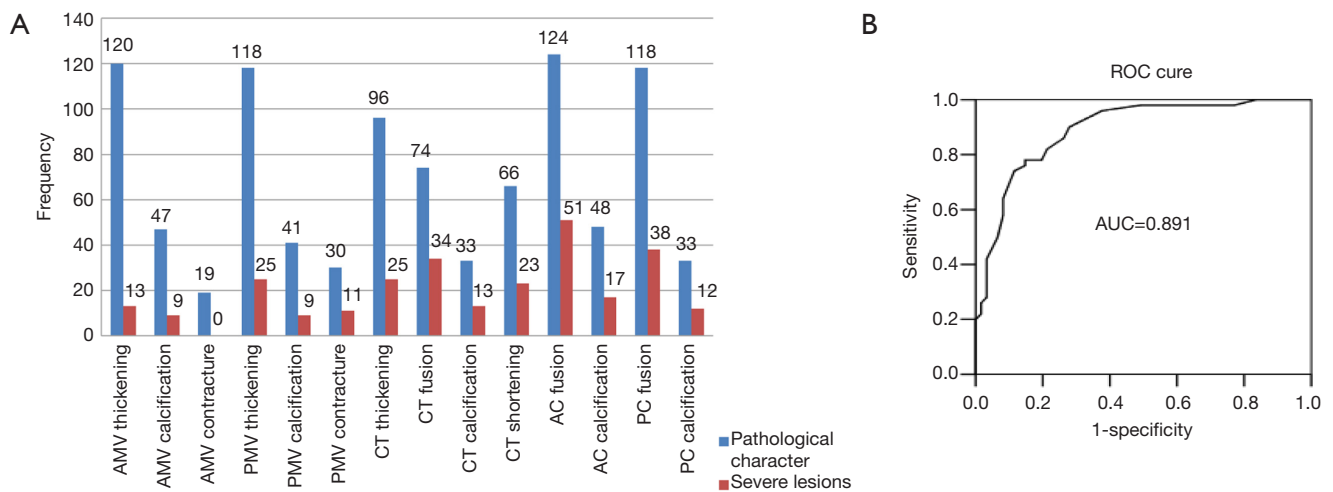


**Figure 1** The median follow-up results of rheumatic mitral valve repair in Chinese patients with the special pathological characteristics. (A) Kaplan-Meier analysis for the percentage of freedom from re-operation with 5 years in the follow-up period. There were 4 patients underwent re-operation. Reason: infective endocarditis (IE) occurred in 2 patients, and regurgitation occurred in the other 2 patients; (B) Kaplan-Meier analysis for the percentage of freedom from valve failure with 5 years in the follow-up period. Valve failure occurred in 16 patients. Reason: regurgitation occurred in 12 patients (2 patients required re-operation); moderate stenosis occurred in 2 patients; IE occurred in 2 patients.

**Table 5** Univariate and multivariate analyses of risk factors for overall endpoint (167 cases)

Statistical variables	Univariate			Multivariate		
	HR	95% CI	P value	HR	95% CI	P value
Age >59 years	0.526	0.150–1.845	0.315			
Sex, female	0.992	0.320–3.077	0.989			
Persistent AF	0.860	0.322–2.292	0.763			
Stenosis	0.621	0.215–1.789	0.377			
Regurgitation	4.365	1.619–11.766	0.004	2.344	0.574–9.569	0.235
Mixed lesion	0.802	0.291–2.207	0.669			
Moderate stenosis/regurgitation, postoperatively	1	0.014–73.65	1			
LVEDD >60 mm, preoperatively	5.991	2.070–17.335	0.001	1.914	0.376–9.738	0.434
LVESD >40 mm, preoperatively	3.039	0.861–10.730	0.084			
LAAPD >60 mm, preoperatively	6.362	2.206–18.348	0.001	3.884	1.569–22.720	0.029
E-wave >200 cm/s, postoperatively	3.141	1.091–9.044	0.034	2.538	0.860–7.492	0.092
Commissurotomy	0.381	0.108–1.337	0.132			
Leaflet thinning	0.429	0.161–1.144	0.091			
Papillary muscle splitting	1.437	0.409–5.050	0.571			
Edge-to-edge	3.617	1.256–10.416	0.017	1.401	0.331–5.939	0.647
Chordal replacement	1.379	0.368–5.161	0.634			
Secondary chordal resection	1.152	0.152–8.761	0.891			
Posterior leaflet plication	0.048	0.000–92,177.999	0.681			

AF, atrial fibrillation; CI, confidence interval; HR, hazard ratio; LAAPD, left atrial anterior and posterior diameter; LVEDD, left ventricular end diastolic dimension; LVESD, left ventricular end systolic diameter.



**Figure 2** Analysis for the pathological characteristics of rheumatic mitral valve. (A) Typical morphological changes of the mitral valve in 126 cases; (B) ROC curve analysis of the PGSRMVL for judgment on whether rMVP would be successful. There were no preoperative plans to repair 15 cases and mitral valve replacement was directly performed; therefore, 111 cases were analysed by ROC curve between September 2015 and June 2016. rMVP, rheumatic mitral valve repair; AC, anterior commissural; AMV, anterior mitral valve; CT, chordae tendineae; PC, posterior commissural; PMV, posterior mitral valve; AUC, area under the curve; PGSRMVL, pathological grading system of rheumatic mitral valve lesions; ROC, receiver operating characteristic.

**Table 6** Seven specific pathological lesions with higher rates in the MVR than rMVP group

Degree of specific pathological lesion	Cases	Percent (%)
ALCAL-III	9	8.11
PLCAL-III	9	8.11
PLCAL-II	10	9.01
CTCAL-II	12	10.81
ACCAL-II	13	11.71
ALCON-II	19	17.12
CTCAL-I	19	17.12

Seven specific pathological lesions must fulfil two criteria: (I)  $P < 0.01$  by the  $\chi^2$  test for rMVP and MVP groups; and (II) be no more than 10% of the total cases. ACCAL-II, anterior leaflet calcification (moderate); ALCAL-III, anterior leaflet calcification (severe); ALCON-II, anterior leaflet contracture (severe); CTCAL-I, chordae tendineae calcification (mild); CTCAL-II, chordae tendineae calcification (severe); PLCAL-II, posterior leaflet calcification (moderate); PLCAL-III, posterior leaflet calcification (severe).

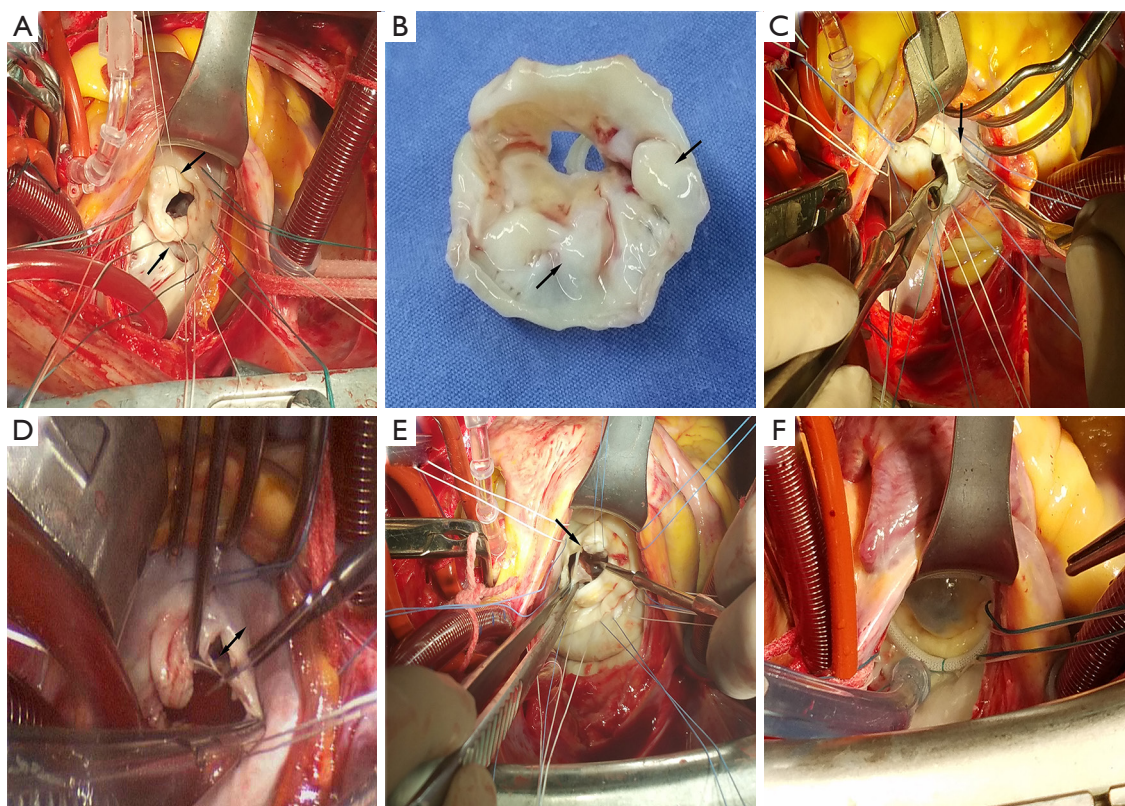
More than 90% of patients with rheumatic disease were found to have leaflet thickening (anterior 95.25%, posterior 93.65%), commissural fusion (anterior 98.41%, posterior 93.65%), and 76% were found to have sub-valvular chordae

**Table 7** Seven specific pathological lesions resulting in different rates of rMVP in surgery

Statistical indexes	None*	Only one*	More than one*
Cases underwent rMVP	52	9	0
Total number of cases	66	19	26
Percent (%) for rMVP	78.79	47.37	0.00

\*, the rheumatic mitral valve showed seven specific pathological lesions on visual observation. rMVP, rheumatic mitral valve repair.

tendineae thickening. However, the percentage of patients with severe pathological lesion of the commissure and sub-valvular apparatus was as high as 30–50%, compared with 0–20% for patients with severe pathological lesion of the leaflet. Therefore, the main pathological characteristics of rheumatic mitral valve disease in Chinese patients are lesions of the commissure and sub-valvular apparatus. These results also could explain why the preoperative echocardiographic pathological types in our centre differ from those in other foreign centres, as the percentage of stenosis and mixed lesion cases were notably higher in our centre than in other centres (3,21). Hence, when we formulated the PGSRMVL, we gave those pathological lesions related to sub-valvular



**Figure 3** The recommendations for commissure processing technique. (A) The two sides of the commissure should be hung; (B) the calcification has involved the full thickness of the leaflet; (C) it should be feasible to cut open a part of commissure close to the annulus; (D) a distance of 2–3 mm should be maintained between the cutting end point and annulus; (E) papillary muscle splitting; (F) the mitral valve recovers a ‘smile’ shape during the water test.

apparatus and calcification a higher weight value, based on special pathological characteristics. Because of the particular pathological characteristics shown among our cases, the surgical techniques used in our centre were also different from those of other centres (4,6,13,22-24). The majority of the patients were treated via commissurotomy (90.5%) and thinning (70.39%). Among all 179 rMVP patients, these two techniques were applied to 122 (68.16%) patients, of which 10 underwent MVR and 112 (91.80%) underwent MVP. By the ROC curve analysis for judgment on whether successful rMVP could be achieved, PGSRMVL was proved to clearly predict the complexity and feasibility of rMVP. However, some points need be explained. First, the pathological score system is complicated and difficult to apply in surgery. Although the analysis between pathological score system and rMVP was significant, scoring every patient is not practical during surgery. Second, the key point of this system is to help us understand the distribution of

rheumatic mitral valve pathological lesions more clearly and reflect the relationship between specific pathological lesions and difficulty of repair. According to the results (Table 7), we can conclude that severe calcification of the commissure and sub-valvular apparatus can considerably decrease the odds of a successful repair.

Based on our experience, we have compiled some recommendations for this type of operation. (I) If the leaflet thickening does not affect leaflet distention, the procedure for thinning is meaningless. (II) The scope of leaflet thinning should be suitable, and the procedure should be stopped when necessary. The aim is to recover leaflet distention. (III) Before commissural leaflet thinning, the two sides of the commissure should be hung and the commissure should be in the plane (Figure 3A). (IV) If calcification has involved the full thickness of the leaflet, it is not helpful to recover leaflet distention by leaflet thinning (Figure 3B). (V) Before commissurotomy, thickening and calcification of the



commissure should be attended to recover the mobility of the commissure. Subsequently, commissurotomy should be performed based on the nature of the commissure border. (VI) When performing commissurotomy, if it is difficult to detect the sub-valvular apparatus, it should be feasible to cut open a part of commissure close to the annulus first, and then to detect and locate the sub-valvular chordae tendineae (Figure 3C). (VII) A distance of 2–3 mm should be maintained between the cutting end point and annulus (Figure 3D). (VIII) Flexibility of the commissure and sub-valvular apparatus should be verified, during the water test. The middle of the commissure should retract; meanwhile, the leaflet should be distended into the middle from both sides of the commissure. (IX) Papillary muscle splitting should be based on the nature of the papillary muscle (Figure 3E). (X) A sign of good prognosis during the water test is that the mitral valve recovers a 'smile' shape (Figure 3F).

With the development of ultrasonic testing technology, especially transesophageal echocardiography (25) and three-dimensional echocardiography, surgeons can plan operations in detail and follow-up on the treatment effect (7). Using multivariate Cox regression analyses for 167 MVP cases, a preoperative LAAPD >60 mm was found to be a significant independent predictor of re-operation and valve failure. A significantly larger left atrial anterior and posterior diameter reflected that the mitral valve lesions had lasted a longer time and the degree of cardiac lesion was more serious; this may also indirectly reflect that the degree of mitral valve lesion was more serious. Therefore, a LAAPD >60 mm can be considered a preoperative predictor of unfavourable prognosis.

Between September 2015 and June 2016, 48.41% patients underwent rMVP in our centre. Considering the large number of patients with rheumatic disease and the low percentage of repair cases, there is still much room for improvement on this subject in China.

This study is limited by its single-centre design and low number of cases. Our findings are susceptible to referral bias and institution-specific practices. Further studies with a longer follow-up period are warranted.

## Conclusions

The main pathological characteristics of rheumatic mitral valve disease in Chinese patients are lesions of the commissure and sub-valvular apparatus. Most patients can be appropriately treated via commissurotomy and leaflet thinning. Severe calcification of the commissure and sub-

valvular apparatus can considerably decrease the odds of a successful repair. The median follow-up results of rMVP are considered satisfactory for the pathological characteristics in Chinese patients, and the use of this procedure should be considered more frequently among surgeons in China.

## Acknowledgements

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## Footnote

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

*Ethical Statement:* The study was approved by the ethics review board of the Capital Medical University affiliated Beijing Anzhen Hospital (No. 857-3) and written informed consent was obtained from all patients.

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