



Impact of mitral annular calcification in mitral valve surgery: 25-year Mayo Clinic experience

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Background: Annular calcification [mitral annular calcification (MAC)] may complicate mitral valve (MV) surgery, and long-term outcome data are limited.

Methods: We reviewed adult patients undergoing MV surgery at our Clinic between January 2000 and December 2024. MAC was identified on preoperative imaging, and operative strategy prioritized repair when feasible and employed conservative debridement when necessary. Patients with MAC were matched 1:1 with patients without MAC using a propensity score.

Results: Among 11,350 MV operations with or without concomitant procedures, 1,603 patients (14.1%) had MAC, the median age was 72.6 years [interquartile range (IQR), 65.3–78.6 years], 54.8% were female. In the MAC cohort, 21% of patients had a prior sternotomy. Concomitant aortic valve replacement (AVR) and coronary artery bypass grafting (CABG) were performed in 32% and 24% of cases, respectively. Compared with propensity-matched controls, MAC patients did not exhibit significantly prolonged cardiopulmonary bypass times (115 *vs.* 112 minutes, $P=0.485$) or aortic cross-clamp durations (86 *vs.* 81 minutes, $P=0.273$). The 30-day hospital readmission rate was significantly higher among MAC patients (15.9% *vs.* 9.9%, $P<0.001$). Although 30-day mortality was elevated in the MAC group (5.8% *vs.* 4.2%), the difference was not statistically significant ($P=0.171$). In a subgroup analysis of matched groups undergoing primary isolated MV surgery, early mortality was 2.7% in patients with MAC and 0.5% in patients without MAC ($P=0.111$). Long-term, 10-year survival was significantly lower in MAC patients (43.6%) compared to matched controls (49.6%, $P<0.001$).

Conclusions: In this large single-center series, patients with MAC often had associated aortic valve and coronary artery disease, and 21% of them were undergoing a second procedure. Compared to matched patients without MAC, long-term survival was reduced in patients with MAC. This experience highlights the importance of accurate preoperative assessment and tailored surgical strategy to achieve acceptable outcomes of MV surgery in the presence of MAC.

Keywords: Mitral valve annuloplasty (MV annuloplasty); mitral valve disorder (MV disorder); mitral valve insufficiency (MV insufficiency); mitral valve stenosis (MV stenosis); calcification



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Introduction

Mitral annular calcification (MAC) is a chronic, degenerative process characterized by calcium deposition in the mitral valve (MV) ring (1,2). It is increasingly recognized in elderly populations and is associated with advanced age, female sex,

hypertension, diabetes, dyslipidemia, and chronic kidney disease (3-6). MAC complicates surgical intervention, particularly in cases of mixed mitral stenosis (MS) and regurgitation when prosthetic replacement is necessary (7,8).

Calcification of the mitral annulus may increase perioperative morbidity in patients undergoing MV

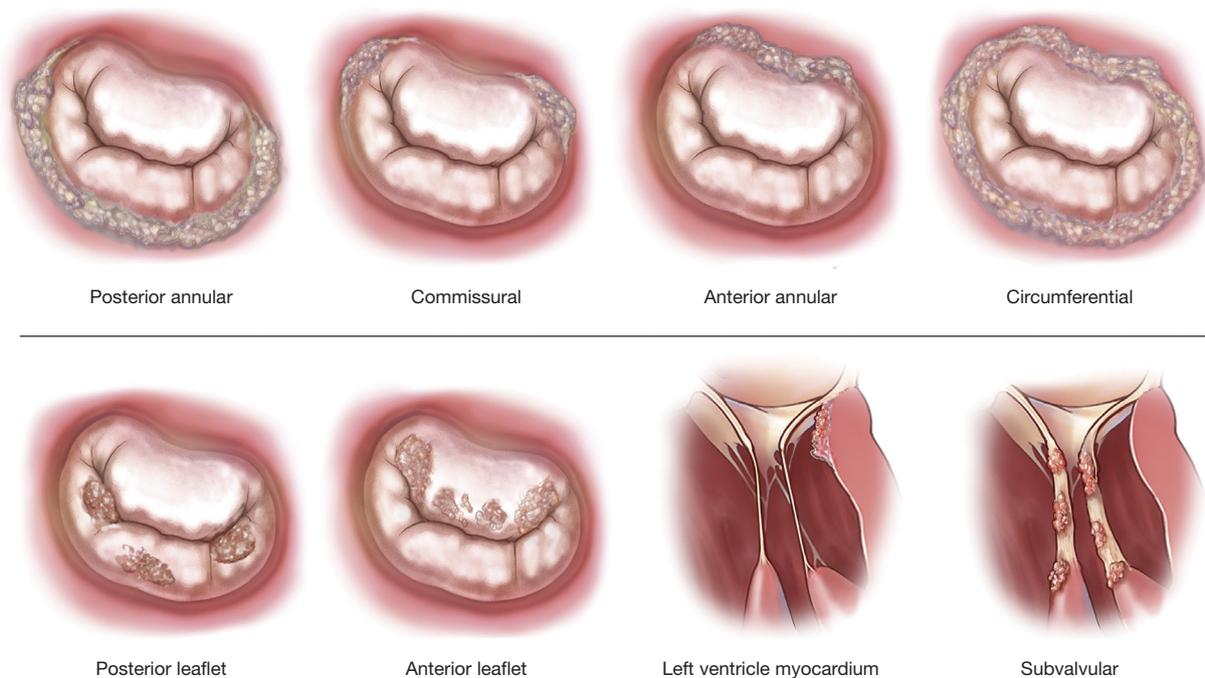


Figure 1 Common sites of calcification in the mitral complex. Adapted with permission from (9).

surgery; risks of bleeding, stroke, arrhythmia, and need for permanent pacemaker have been reported to be higher in MAC patients (3,9). Secure prosthesis implantation may be difficult due to annular rigidity. Even in experienced centers, these challenges are associated with higher rates of complications such as bleeding, prolonged hospitalization, and early postoperative morbidity (3,10).

Although the potential procedural risks associated with MAC are well-recognized, there is relatively little information on late outcomes of MV surgery in patients with MAC. Indeed, long-term outcomes in patients with MAC might be expected to be less favorable compared to those of patients without MAC due to coexisting conditions such as chronic kidney disease, multivalvular involvement, and atrial fibrillation, which may contribute to reduced durability of intervention and increased late mortality (9).

We therefore sought to provide a comprehensive description of early and late outcomes of MV surgery in patients with MAC over 25 years at our center. This study assesses the prevalence, perioperative characteristics, and early and late outcomes of patients undergoing MV surgery in the setting of MAC. Additionally, we compared these outcomes with those of a propensity-matched control group.

Methods

Study design and patient population

To understand the impact of MAC on early and late outcomes of MV procedures, we analyzed all adult patients (age ≥ 18 years) who underwent MV surgery (repair or replacement) at our Clinic between January 2000 and December 2024. We defined MAC as any degree of calcification of the mitral annulus noted on preoperative imaging, including echocardiography, chest radiography, computed tomography, or coronary angiography reports. The variable severity and extent of MAC are illustrated in *Figure 1*. Patients undergoing emergent mitral operations were excluded to avoid confounding extreme operative urgency with MAC-related risk. If patients had multiple mitral operations in the study period, only the first (index) operation was considered.

Surgical technique and intraoperative management

Surgeons at our clinic have generally followed a conservative approach to managing MAC during MV procedures. If the MV was judged repairable, valvuloplasty was favored even in the presence of annular calcium. Techniques for repair

included cleft closures, leaflet resection or augmentation, and artificial chordal placement. Use of an annuloplasty band was individualized depending on the flexibility of annular tissue. In some patients, annular calcification prevented secure suture of a portion of the annulus, and a shortened band or suture annuloplasty (Kay-Reed type) (11,12) was employed to reduce circumference and stabilize leaflet repair. When calcification prevented annuloplasty, valvuloplasty was performed by leaflet repair alone (13).

In cases of MV replacement, the management of MAC was individualized based on the extent and location of calcium. Annular calcium that did not interfere with the seating of the prosthesis was left intact. Decalcification was done cautiously, when necessary, with removal of calcium only to the extent needed to allow an adequately sized prosthetic valve to be seated securely. Care was taken to avoid deep disruption of the atrioventricular groove and injury to the circumflex artery. The approach to MV replacement employed in these patients has been outlined in a prior publication (9). Concomitant procedures [e.g., coronary artery bypass grafting (CABG), aortic valve replacement (AVR), tricuspid valve repair] were performed as indicated.

In rare instances, patients with extensive MAC underwent MV bypass, as previously described (14).

Statistical analysis

Categorical variables were reported as numbers (percentage), and continuous variables were reported as medians [25th through 75th interquartile range (IQR)]. To account for baseline differences between patients with and without MAC, our MAC patients were 1:1 propensity score-matched to non-MAC patients. The propensity scores were derived from a multivariable logistic regression for predicting distance group using the following potential confounders: age, sex, procedure type (repair *vs.* replacement), history of prior sternotomy, any concomitant cardiac procedure, CABG, AVR, or tricuspid valve repair, preoperative left ventricular ejection fraction (EF), primary mitral pathology (regurgitation and/or stenosis), and key comorbidities (diabetes mellitus, peripheral arterial disease, and chronic kidney disease). Nearest neighbor matching was used with a caliper of 0.2 of the standard deviation of the propensity scores. As appropriate, comparisons between groups were made using paired *t*-tests, Wilcoxon Signed Rank, or McNemar tests. Unadjusted survival curves were constructed using the Kaplan-Meier estimator, and P values

were calculated with the log-rank test for the primary outcome. Statistical significance was defined at a $P < 0.05$. All statistical analyses were performed using R software (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria). The study was approved by the Mayo Clinic Institutional Review Board (#25-00561, July 17 2025), with a waiver of individual consent for retrospective analysis.

Results

Baseline characteristics of all patients with MAC undergoing MV surgery

During the 25-year period from January 2000 to December 2024, 11,350 MV operations were performed at our Clinic, and 1,603 (14.1%) patients had MAC. The median age of the MAC group was 72.6 years (IQR: 65.3–78.6 years), and 54.8% were female. As seen in [Table S1](#), this cohort presented as an older and much sicker group of patients compared to the larger group of MV surgical patients; cerebrovascular disease was present in 21%, peripheral vascular disease was recorded in 13%, and renal failure was a feature in 6%. Most patients presented with advanced symptoms, with the majority (66.8%) in New York Heart Association (NYHA) functional class III or IV. Atrial fibrillation was reported in 31%, and 21% had prior cardiac surgery by sternotomy.

A patient with MAC can present with mitral regurgitation (MR) and/or MS. Because patients with MS may have worse outcomes, we further subgrouped the patients according to the presence or absence of MS. Of 1,603 patients with MAC, 619 (39%) had MS (with or without some degree of MR), while the remainder had MR. [Table 1](#) summarizes the baseline characteristics of patients with MAC and groups stratified by MV regurgitation alone or with stenosis.

Operative and early postoperative outcomes of patients with MAC

Among patients with MAC, 42% underwent mitral repair while 58% had valve replacement. As seen in [Table 2](#), concomitant operations were common; one-third of patients with MAC underwent concomitant aortic valve surgery, and among MAC patients with MS, 50% underwent an aortic valve procedure. Median cross-clamp time was 82 minutes (IQR, 55–117 minutes) and was longer in the presence of MS ($P < 0.001$). Patients with MS had twice the rates of dialysis and pneumonia, and had more extended intensive care unit (ICU) stay, higher readmission, and 30-day

Table 1 Clinical characteristics of patients with MAC undergoing mitral valve surgery

Variables	All (N=1,603)	MR (N=984)	MS (N=619)	P value
Age (years)	72.6 (65.3–78.6)	73.2 (66.5–79.3)	71.2 (62.9–77.5)	<0.001
Sex (female)	879 (54.8)	468 (47.6)	411 (66.4)	<0.001
BMI (kg/m ²)	28.1 (24.5–32.3)	27.6 (24.4–31.2)	29.1 (25.1–34.1)	<0.001
Diabetes	394 (24.6)	175 (17.8)	219 (35.4)	<0.001
Renal failure	104 (6.5)	43 (4.4)	61 (9.9)	<0.001
Dyslipidemia	1234 (77.0)	735 (74.7)	499 (80.6)	0.006
Coronary artery disease	766 (47.8)	445 (45.2)	321 (51.9)	0.009
Peripheral vascular disease	210 (13.1)	97 (9.9)	113 (18.3)	<0.001
Smoking history	741(46.3)	422 (42.9)	319 (51.5)	0.002
NYHA class 3 or 4	970 (66.8)	526 (59.6)	444 (77.7)	<0.001
Recent AFib/Aflutter	499 (31.1)	328 (33.3)	171 (27.7)	0.093
Previous sternotomy	213 (21.3)	97 (15.7)	116 (30.2)	<0.001
Previous CABG	182 (11.4)	95 (9.7)	87 (14.1)	0.007
Previous AV intervention	213 (13.2)	92 (9.3)	121 (19.5)	<0.001
Previous MV intervention	110 (6.8)	44 (4.5)	66 (10.6)	<0.001
Permanent pacemaker	187 (11.7)	94 (9.6)	93 (15.0)	<0.001
Ejection fraction (%)	63.0 (57.0, 67.0)	62.0 (55.0, 66.0)	65.0 (60.0, 70.0)	<0.001
PASP (mmHg)	48.0 (37.0, 62.0)	44.0 (34.0, 57.0)	54.0 (42.5, 68.0)	<0.001
Aortic stenosis	590 (36.8)	231 (23.5)	359 (58.0)	<0.001
Moderate or greater TR	720 (45)	421 (42.9)	299 (48.3)	0.040

Values are presented as n (%) or median (interquartile range). AFib/Aflutter, atrial fibrillation or flutter; AV, aortic valve; BMI, body mass index; CABG, coronary artery bypass grafting; MAC, mitral annular calcification; MR, mitral regurgitation; MS, mitral stenosis; MV, mitral valve; NYHA, New York Heart Association; PASP, pulmonary artery systolic pressure; TR, tricuspid valve regurgitation.

mortality (Table 2). Early reoperation for valve dysfunction was rare and recorded in only 1.2% of patients with MAC. The overall operative mortality risk in patients with MAC was 6.6% and was higher in patients with MS. Over the 25-year study period, 5 patients (0.3%) experienced atrioventricular groove disruption; all died during the index hospitalization. Notably, although the number of patients with MAC undergoing mitral surgery increased over time, the operative mortality risk decreased over the study period (Figure S1).

Late survival of patients with MAC undergoing MV surgery

Among the 1,603 patients included in the study, 882 deaths

occurred over a median follow-up of 9.3 years (IQR, 4.6–15.6 years). Figure 2 illustrates the long-term survival for patients with MAC who underwent mitral surgery. As seen in Figure 2B, overall survival was significantly reduced in MAC patients with MV stenosis in univariate analysis.

Propensity score-matched analysis

Using propensity score matching, 1,017 patients with MAC were matched 1:1 to 1,017 control patients without MAC who underwent MV surgery based on variables described in the methods section. Baseline differences between the two groups are presented in Table S1. Matching resulted in generally comparable cohorts, as demonstrated in the covariate balance graph (Figure 3).

Table 2 Surgical outcomes of patients with MAC undergoing mitral valve surgery

Variables	All (N=1,603)	MR (N=984)	MS (N=619)	P value
Perfusion time (minutes)	112.0 (77.5–157.0)	100.0 (71.0–144.0)	129.0 (94.0–183.0)	<0.001
Cross-clamp time (minutes)	82.0 (55.0–117.0)	72.0 (49.0–104.0)	98.0 (70.5–138.0)	<0.001
Concomitant CABG	387 (24.1)	257 (26.1)	130 (21.0)	0.019
Concomitant AV replacement	518 (32.3)	218 (22.1)	300 (48.5)	<0.001
Concomitant TV repair	360 (22.4)	225 (22.8)	135 (21.8)	0.621
Postoperative renal failure	165 (10.3)	76 (7.7)	89 (14.4)	<0.001
Postoperative stroke	34 (2.1)	21 (2.1)	13 (2.1)	0.963
Postoperative AFib	551 (34.4)	325 (33.0)	226 (36.5)	0.153
Pneumonia	143 (8.9)	64 (6.5)	79 (12.8)	<0.001
Length of ICU stay (hours)	45.5 (23.5–97.8)	38.0 (22.5–73.5)	69.7 (28.1–136.7)	<0.001
Length of hospital stay (days)	8.0 (6.0–12.0)	7.0 (5.0–10.0)	9.0 (7.0–14.0)	<0.001
30-day readmission	193 (13.6)	97 (10.9)	96 (18.1)	<0.001
30-day mortality	105 (6.6)	43 (4.4)	62 (10.1)	<0.001

Values are presented as n (%) or median (interquartile range). AFib, atrial fibrillation; AV, aortic valve; CABG, coronary artery bypass graft; ICU, intensive care unit; MAC, mitral annular calcification; MR, mitral regurgitation; MS, mitral stenosis; TV, tricuspid valve.

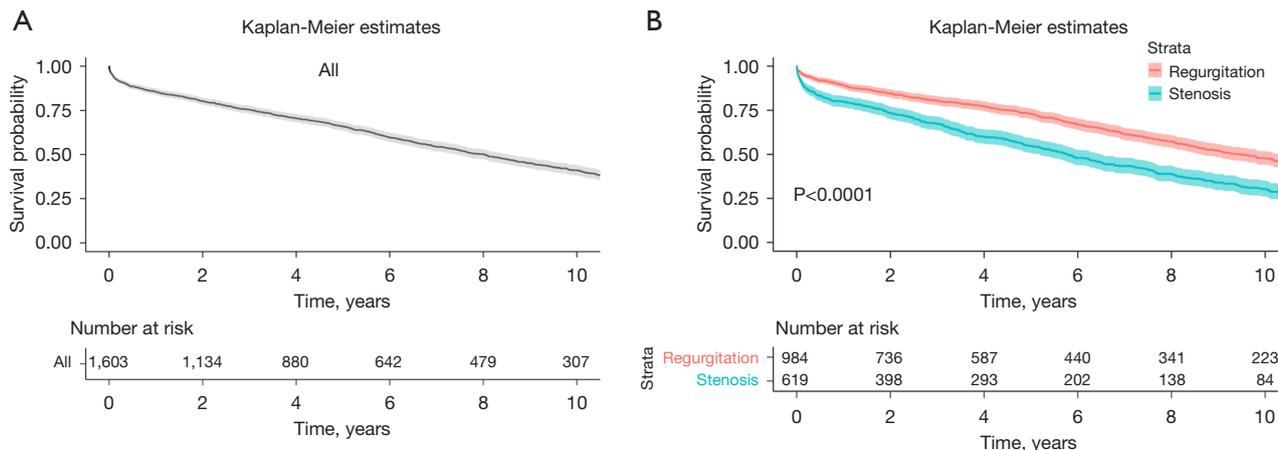


Figure 2 Long-term survival. (A) Survival probability among patients with mitral annular calcification who underwent mitral valve surgery. (B) Survival following mitral valve surgery in patients with mitral annular calcification, stratified by stenosis *vs.* regurgitation.

Postoperative outcomes, including early complications and long-term survival, were then compared between the matched groups to assess the effect of MAC on surgical prognosis. Postoperatively, pneumonia and sternal infection occurred more in MAC patients (9.6% *vs.* 6.7%, $P=0.018$; 0.5% *vs.* 1.6%, $P=0.029$) than in patients without MAC.

Other postoperative complications (*Figure 4*) were rare and similar between both groups.

Intraoperatively, the median cardiopulmonary bypass time was 115 *vs.* 112 minutes ($P=0.485$), and the mean cross-clamp time was 86 *vs.* 81 minutes ($P=0.273$), both comparable between groups. A higher proportion of

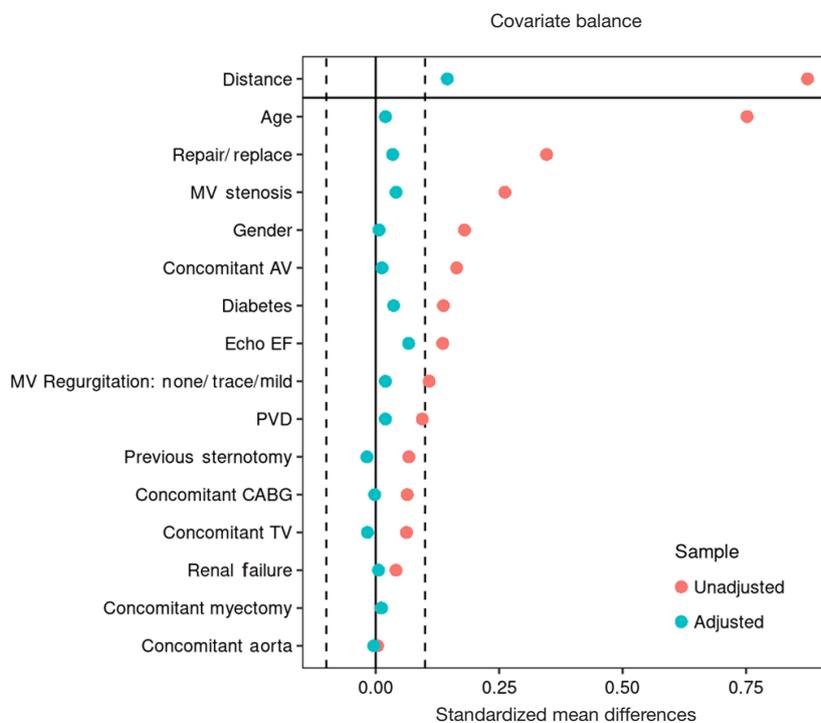


Figure 3 Standardized mean differences for covariates before and after propensity score matching. AV, aortic valve; CABG, coronary artery bypass grafting; EF, ejection fraction; MV, mitral valve; PVD, peripheral vascular disease; TV, tricuspid valve.

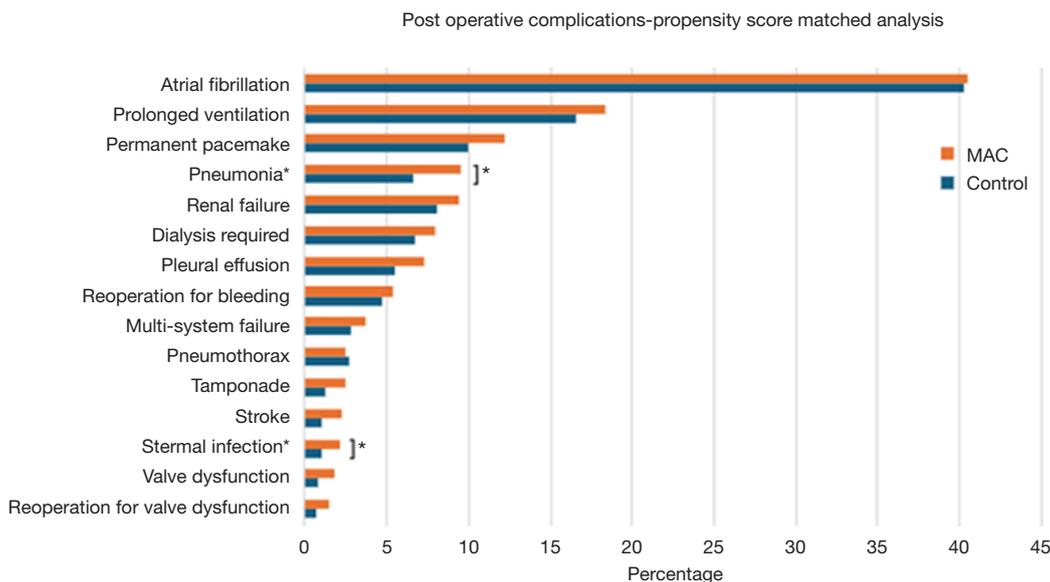


Figure 4 Postoperative complications—rates of postoperative sternal infection and pneumonia were higher in the MAC group (1.1% vs. 2.2%, $P=0.029$; 6.7% vs. 9.6%, $P=0.018$), and postoperative stroke had a higher incidence in the MAC group (1.1% vs. 2.3%, $P=0.059$). *, statistically significant difference ($P<0.05$). MAC, mitral annular calcification.

Table 3 Operative findings and early outcomes—propensity score matched analysis

Variables	Control (N=1,017)	MAC (N=1,017)	P value
Intraoperative blood products used	606 (59.6)	653 (64.2)	0.020
Perfusion time (minutes)	112.0 (77.0–164.0)	115.0 (82.0–166.8)	0.485
Cross-clamp time (minutes)	81.0 (54.0–120.0)	86.0 (57.0–124.0)	0.273
Length of ICU stay (hours)	42.0 (22.3–80.6)	45.6 (22.9–113.9)	0.010
Length of hospital stay (days)	7.0 (5.0–10.0)	7.0 (5.0–12.0)	0.054
30-day readmission	88 (9.9)	136 (15.9)	<0.001
30-day mortality	43 (4.2)	59 (5.8)	0.171

Values are presented as n (%) or median (interquartile range). ICU, intensive care unit.

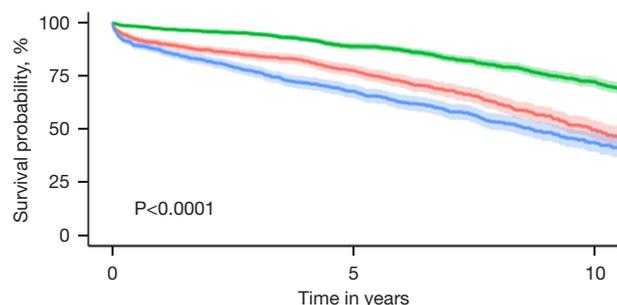


Figure 5 Survival of all patients with mitral annular calcification (blue line) vs. propensity score-matched control group (red line), vs. age (average 72 years) and sex (58% female) matched control group of primary isolated mitral valve surgery without mitral annular calcification (green line).

patients with MAC required intraoperative blood products than those without MAC (64.2% vs. 59.6%, $P=0.020$).

The ICU length of stay was longer in patients with MAC (45.6 vs. 42.0 hours, $P=0.010$), whereas the total length of hospitalization did not differ significantly between the MAC and no MAC matched groups (7 vs. 7 days, $P=0.54$).

Mortality rate in the first 30 days after surgery (5.8% vs. 4.2%, $P=0.171$) was not statistically different between the two groups. In subgroup analysis, patients undergoing primary isolated MV surgery had a mortality rate of 2.7% (5 patients) in patients with MAC and 0.5% (1 patient) in patients without MAC ($P=0.111$). Readmission rates were higher in the MAC group (15.9% vs. 9.9%, $P<0.001$, Table 3). Long-term survival analysis revealed a significantly worse outcome over 10 years in patients with MAC. As seen in Figure 5, the probabilities of 1-year (86.9% vs. 90.1%),

5-year (67.8% vs. 77.4%), and 10-year survival (43.6% vs. 49.6%) were all worse in patients with MAC compared to propensity-matched patients without calcification.

Discussion

This study provides a comprehensive overview of patients with MAC undergoing MV surgery at our center over the past 25 years. Using subgroup analyses and propensity score matching, we evaluated the impact of MAC on both early and late surgical outcomes. Our findings reaffirm the complex clinical profile of this patient population and highlight the persistent challenges in surgical management, including reduced long-term survival of patients with MAC compared to matched controls.

Studies suggest that the prevalence of MAC ranges between 5% and 15% in the general population, increasing to >40% in the elderly (15). Kaneko *et al.* reported a prevalence of 18.1% for MAC in mitral surgery patients based on the STS database between 2011 and 2017, which is generally comparable with the 14.1% prevalence in the present investigation (16). Different study intervals, variable definitions, and identification methods may explain the slightly lower prevalence in our data.

Consistent with prior investigations, our MAC cohort was elderly, predominantly female, and frequently affected by chronic comorbid conditions such as diabetes mellitus, peripheral vascular disease, and chronic kidney disease (15,17). Similar findings were identified by Fukui *et al.* in a study of patients undergoing transthoracic echocardiography. These authors also found an association of aortic stenosis with MS among patients with MAC. As

expected, their patients were less symptomatic than our surgical cohort, but importantly, they found that survival at 3-year follow-up was improved in those who had mitral intervention (78% vs. 50%; $P < 0.001$) (17).

An important finding in the present analysis is the greater perioperative risk of patients with MAC and MS. This might be expected as leaflet calcification and stiffening is a manifestation of more advanced cardiac disease. Indeed, almost half of the patients with MAC and MS in the present study required concomitant valve replacement for aortic stenosis. The additional complexity of mitral surgery, including the need for prosthetic replacement, increases operative morbidity and mortality. These findings are similar to previous reports highlighting the challenges of treating MS due to MAC (18). Surgeons who encounter extensive MAC in a patient with MS should be familiar with decalcification techniques, alternate suture methods, and novel use of balloon-expandable prostheses for valve substitutes, as described in detail by El-Eshmawi *et al.* (10). As mentioned previously, we have favored limited annular decalcification when feasible, and this strategy has yielded satisfactory results. Early reoperation for valve dysfunction or perivalvular prosthetic leak was rare, occurring in only 1.2% of patients with MAC. In parallel with advances in perioperative care and surgical technology, operative outcomes, including mortality, have improved (Figure S1), aligning with earlier reports (19,20).

Although extensive calcium deposition in the mitral annulus, leaflets, or chordae can make MV repair technically challenging, MAC on preoperative evaluation should not be considered a contraindication to valvuloplasty for patients with MR. Indeed, MV repair was successfully performed in nearly half of our MAC cohort. This is consistent with the recently published expert consensus regarding the feasibility of MV repair in non-extensive MAC in patients with MR (21).

In contemporary practice, the availability of percutaneous valve insertion has expanded options for symptomatic patients with MV disease and severe MAC, especially for patients who are poor surgical candidates due to frailty or associated disease (22). Transcatheter edge-to-edge repair can be used in selected cases of MR, but outcomes are less durable in MAC due to residual or progressive stenosis and higher mortality. Valve-in-MAC with balloon-expandable aortic transcatheter valves, most commonly SAPIEN devices, have become feasible via a transseptal approach,

though left ventricular outflow tract obstruction remains a major obstacle; strategies like alcohol septal ablation or the LAMPOON procedure (leaflet laceration) help mitigate this. Dedicated transcatheter MVs such as Tendyne, Intrepid, and SAPIEN M3 are being evaluated in clinical trials and may have better outcomes due to better anatomic fit and the ability to reposition the prosthesis. These options should be discussed with patients who have extensive MAC, especially those with comorbidities that would be expected to increase surgical risk.

The presence of MAC itself was not associated with increased operative mortality or major postoperative complications; however, beyond the immediate perioperative period, long-term outcomes in MAC patients remained inferior. Our survival analysis aligns with prior studies reporting lower 5- and 10-year survival in this group. This diminished prognosis is likely multifactorial, reflecting not only the burden of comorbidities but also the structural and technical limitations that MAC imposes during surgery.

In summary, patients with MAC have more comorbidities and present with concomitant aortic valve and coronary artery disease. Even after adjusting for these factors in our matched cohort, MAC remained linked to poorer long-term outcomes, although immediate post-operative mortality and major complications were generally similar between groups. Our findings show that, with careful selection, MV repair can be successfully achieved in 42% of MAC patients. This experience highlights the importance of accurate preoperative assessment and tailored surgical strategy to achieve acceptable outcomes of MV surgery in the presence of MAC.

Limitations

The retrospective design and long study interval may introduce selection bias and limit the ability to establish causal relationships from our data. The results reflect the experience of a single, high-volume center, potentially affecting the generalizability of the findings to other settings. Additionally, incomplete long-term echocardiographic follow-up restricted the assessment of late failure of valve repair and replacement. While our study reflects real-world surgical outcomes in MAC patients, the findings should be interpreted within the context of these constraints.

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Footnote

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

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References

1. Korn D, Desanctis RW, Sell S. Massive calcification of the mitral annulus. A clinicopathological study of fourteen cases. *N Engl J Med* 1962;267:900-9.
2. Fox CS, Vasan RS, Parise H, et al. Mitral annular calcification predicts cardiovascular morbidity and mortality: the Framingham Heart Study. *Circulation* 2003;107:1492-6.
3. Churchill TW, Yucel E, Deferm S, et al. Mitral Valve Dysfunction in Patients With Annular Calcification: JACC Review Topic of the Week. *J Am Coll Cardiol* 2022;80:739-51.
4. Kato N, Guerrero M, Padang R, et al. Prevalence and Natural History of Mitral Annulus Calcification and Related Valve Dysfunction. *Mayo Clin Proc* 2022;97:1094-107.
5. Museedi AS, Le Jemtel TH. Mitral Annular Calcification-Related Valvular Disease: A Challenging Entity. *J Clin Med* 2024;13:896.
6. Elmariah S, Budoff MJ, Delaney JA, et al. Risk factors associated with the incidence and progression of mitral annulus calcification: the multi-ethnic study of atherosclerosis. *Am Heart J* 2013;166:904-12.
7. Edelman JJ, Badhwar V, Larbalestier R, et al. Contemporary Surgical and Transcatheter Management of Mitral Annular Calcification. *Ann Thorac Surg* 2021;111:390-7.
8. Groenewoud R, Rokui S, Gottschalk BH, et al. Long-Term Outcomes After Mitral Valve Replacement in Sex- and Age-Matched Patients With vs Without Mitral Annular Calcification. *CJC Open* 2025;7:649-56.
9. Saran N, Greason KL, Schaff HV, et al. Does Mitral Valve Calcium in Patients Undergoing Mitral Valve Replacement Portend Worse Survival? *Ann Thorac Surg* 2019;107:444-52.
10. Chehab O, Roberts-Thomson R, Bivona A, et al. Management of Patients With Severe Mitral Annular Calcification: JACC State-of-the-Art Review. *J Am Coll Cardiol* 2022;80:722-38.
11. KAY JH, EGERTON WS. The repair of mitral insufficiency associated with ruptured chordae tendineae. *Ann Surg* 1963;157:351-60.
12. Reed GE, Tice DA, Clauss RH. Asymmetric exaggerated mitral annuloplasty: repair of mitral insufficiency with hemodynamic predictability. *J Thorac Cardiovasc Surg* 1965;49:752-61.
13. Yacoub M, Halim M, Radley-Smith R, et al. Surgical treatment of mitral regurgitation caused by floppy valves: repair versus replacement. *Circulation* 1981;64:II210-6.
14. Qamar Y, Karadzha A, Schaff HV. LA-to-LV Valved Conduit for Relief of Mitral Stenosis in Patients With HCM and Severe MAC. *JACC Case Rep* 2024;29:102409.
15. Mendez-Hirata G, Schmidt CW, Bashir HI, et al. Mitral Annular Calcification: Natural History, Prognosis, and Clinical Outcomes. *J Soc Cardiovasc Angiogr Interv* 2025;4:103732.
16. Kaneko T, Hirji S, Percy E, et al. Characterizing Risks Associated With Mitral Annular Calcification in Mitral Valve Replacement. *Ann Thorac Surg* 2019;108:1761-7.
17. Fukui M, Cavalcante JL, Ahmed A, et al. Clinical Outcomes of Mitral Valve Disease With Mitral Annular Calcification. *Am J Cardiol* 2022;174:107-13.
18. Pizano A, Hirji SA, Nguyen TC. Severe Mitral Annular Calcification and Mitral Valve Surgery: An Algorithmic Approach to Management. *Semin Thorac Cardiovasc Surg* 2020;32:630-4.
19. Papadopoulos N, Dietrich M, Christodoulou T, et al. Midterm survival after decalcification of the mitral annulus. *Ann Thorac Surg* 2009;87:1143-7.
20. Tomšič A, Hiemstra YL, van Brakel TJ, et al. Outcomes of Valve Repair for Degenerative Disease in Patients

- With Mitral Annular Calcification. *Ann Thorac Surg* 2019;107:1195-201.
21. El-Eshmawi A, Halas M, Bethea BT, et al. The American Association for Thoracic Surgery (AATS) 2025 Expert Consensus Document: Surgical management of mitral annular calcification. *J Thorac Cardiovasc Surg* 2025;170:502-22.
22. Urena M, Kikoïne J, Guerrero M. Mitral Annular Calcification: Understanding the Disease and Treatment Options. *Struct Heart* 2025;9:100668.

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