



Mitral valve surgery in mitral annular calcification

Martin Misfeld^{1,2,3,4}, Tristan D. Yan^{1,2,3}

¹Department of Cardiothoracic Surgery, Royal Prince Alfred Hospital, Sydney, Australia; ²Department of Cardiothoracic Surgery, Sydney Adventist Hospital, Sydney, Australia; ³Sydney Medical School, University of Sydney, Sydney, Australia; ⁴Department of Cardiothoracic Surgery, Macquarie University Hospital, Sydney, Australia

Correspondence to: Martin Misfeld, MD, PhD, FRACS. Department of Cardiothoracic Surgery, Royal Prince Alfred Hospital, 50 Missenden Road, Camperdown, Sydney, NSW 2050, Australia; Department of Cardiothoracic Surgery, Sydney Adventist Hospital, Sydney, Australia; Sydney Medical School, University of Sydney, Sydney, Australia; Department of Cardiothoracic Surgery, Macquarie University Hospital, Sydney, Australia. Email: martinmisfeld@yahoo.com.

Mitral annular calcification (MAC) remains a challenging pathology in the context of mitral valve disease. It is associated with known cardiovascular risk factors, as well as a variety of chronic inflammatory, infective, or connective tissue diseases. Surgically, patients are at specific operative risk for atrioventricular dehiscence or rupture and/or injury to the circumflex artery. To mitigate these risks, a broad portfolio of surgical options exists to safely anchor annular sutures. This can be performed after the calcium bar has been removed and the posterior annulus reconstructed with a patch, or even when the calcium bar is left in place. Knowledge of these techniques will help surgeons manage MAC and implant a properly sized valve. Even in the presence of severe MAC with additional involvement of the mitral valve leaflets, transatrial transcatheter heart valve (THV) implantation may be a viable option. An individualized decision-making process to determine the applicable technique should be used for patients with MAC, leading to adequate treatment for this high-risk patient group.

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Introduction

Mitral annular calcification (MAC) was first described by Bonninger in 1908 in a patient with heart block (1). It is estimated that MAC is present in up to 10–15% of the elderly population, with prevalence increasing further with advancing age (2,3). In about three-quarters of patients, the posterior annulus is involved (4). The pathomechanism leading to MAC is not fully understood. However, there is a clear relation to cardiovascular risk factors such as diabetes mellitus, arterial hypertension, smoking, and hyperlipoproteinemia. Further risk factors include age, female gender, obesity, renal failure, ethnicity, and interleukin-6, a mediator of inflammation and immunity (4,5). There is also an association with infective endocarditis, coronary artery disease, congestive heart failure (6), and stroke (7). In addition, persons with

fibroelastic deficiency, Barlow's, or Marfan's disease are at increased risk of developing MAC (8). There is evidence that local inflammation and calcification activation induce a self-perpetuating cycle (9), which is also triggered by increased hemodynamic stress (10). An imbalance between promoters of osteogenic transformation and/or inhibition of mineralization may also play a role in MAC pathogenesis (11).

MAC is asymptomatic in the majority of patients and is an incidental finding during cardiovascular imaging. With progression of this degenerative process over time, calcification may also affect mitral valve leaflets and commissures. However, in contrast to rheumatic mitral valve disease with thickening and calcified leaflets and commissures, MAC is characterized by initial calcium deposit in the fibrous annulus. Both pathologies can progress to the other and be associated with mitral valve

regurgitation and/or stenosis.

If mitral valve disease is present, surgical correction in the presence of MAC can be challenging. Often valve-preserving techniques are not possible, and valve replacement is required. Anchoring an artificial prosthesis in the presence of MAC requires an individual approach as the degree of MAC varies. Potential surgical risks such as improper valve size, injury of the circumflex artery, injury of the conduction system, and atrio-ventricular dehiscence have to be avoided.

There are a variety of surgical techniques to address these challenges, with a focus on addressing MAC through a standard surgical access with full sternotomy. They are described in this illustrative article.

Operative techniques

Preparation and exposure

Depending on the surgical access, the patient is positioned in a supine position for standard access via full or partial sternotomy or in a position with the right side of the chest slightly elevated for a minimally invasive surgical (MIS) approach with a right thoracotomy. Establishing cardiopulmonary bypass also follows standard principles of the specific surgical access with either central cannulation or peripheral cannulation for a MIS technique. In the presence of severe MAC, most surgeons would avoid a MIS technique, as potential reconstruction of the mitral annulus can be challenging via this approach.

The mitral valve is exposed in a standard fashion either through Sondergaard's groove, a trans-septal approach, or the roof of the left atrium. As MAC can have various degrees and distribution of calcium (*Figure 1A-1F*), adequate exposure of the mitral valve is essential to have access to all areas of the mitral valve apparatus involved.

Operation

If only partial calcification of the posterior annulus is present, it is often possible to pass the sutures around single calcium deposits or partially through the preserved posterior leaflet to anchor a valve. Non-everted U-sutures should be used instead of an everted suture technique to avoid tearing of the sutures out of the annulus. In the presence of severe posterior MAC, however, complete removal of the calcium bar may sometimes be required. To accomplish this, the posterior mitral leaflet (PML) is detached from the

transition area between the leaflet and the left atrium. A retraction suture is used to retract the PML for visualization of the calcium bar (*Figure 2A*). The bar should be resected using scissors and/or the cautery at a low energy level (*Figure 2B*). Care has to be taken not to damage the cardiac vessels. Meticulous hemostasis is essential. The area of the posterior annulus is then reconstructed using an autologous or bovine pericardial patch. The patch is shaped in a way that follows the curved shape of the posterior annulus. Oversizing should be avoided, as potential bleeding under the patch could cause bulging. A running 4/0 or 3/0 monofilament suture is used. Additionally, pledgeted reinforced U-sutures may be used for reinforcement of the patch towards the ventricular side. These sutures are passed through the ventricular muscle and the patch (*Figure 3A*). In case the mitral valve is repaired, the PML may be reattached to the patch. However, in most cases, the mitral valve needs to be replaced. Sutures are then passed through the preserved PML and the patch twice, or through the leaflet, followed by the patch and the left atrial muscle (*Figure 3B*). Before sutures are placed into the anterior annulus, the anterior mitral leaflet (AML) is either completely resected with preserved chordae to the PML or it can be split with additional preserved chordae to the AML (*Figure 3B*). Sutures are then passed through the remaining annulus in a standard fashion with a preference for using a non-everted suture technique. After tying the sutures, the valve is safely secured with the posterior patch visible (*Figure 3C*).

As an "en-bloc" removal of the posterior calcium bar has the potential risk of coronary artery damage, atrio-ventricular dehiscence, or rupture, an alternative technique is to keep the MAC in place and pass interrupted, reinforced U-sutures underneath the posterior calcium bar. Starting from the ventricular side, multiple 3/0 monofilament U-sutures with a large needle are used. The sutures are passed through a pericardial or Teflon strip, which acts as a reinforcement (*Figure 4A*). Sutures are either passed under the calcium bar (*Figure 4B*) or, if possible, through it. The patch and the endothelium-covered calcium bar will prevent mobilization of calcium particles. The sutures are then used to anchor the prosthesis in the posterior annular area. In some instances, sutures cannot be passed underneath or through the calcium bar. They are then passed as non-everting sutures through the preserved PML, anterior to the annulus, and through a pericardial patch. This patch will be used to further reinforce the prosthetic valve and to avoid paravalvular leakage by anchoring the patch to the left

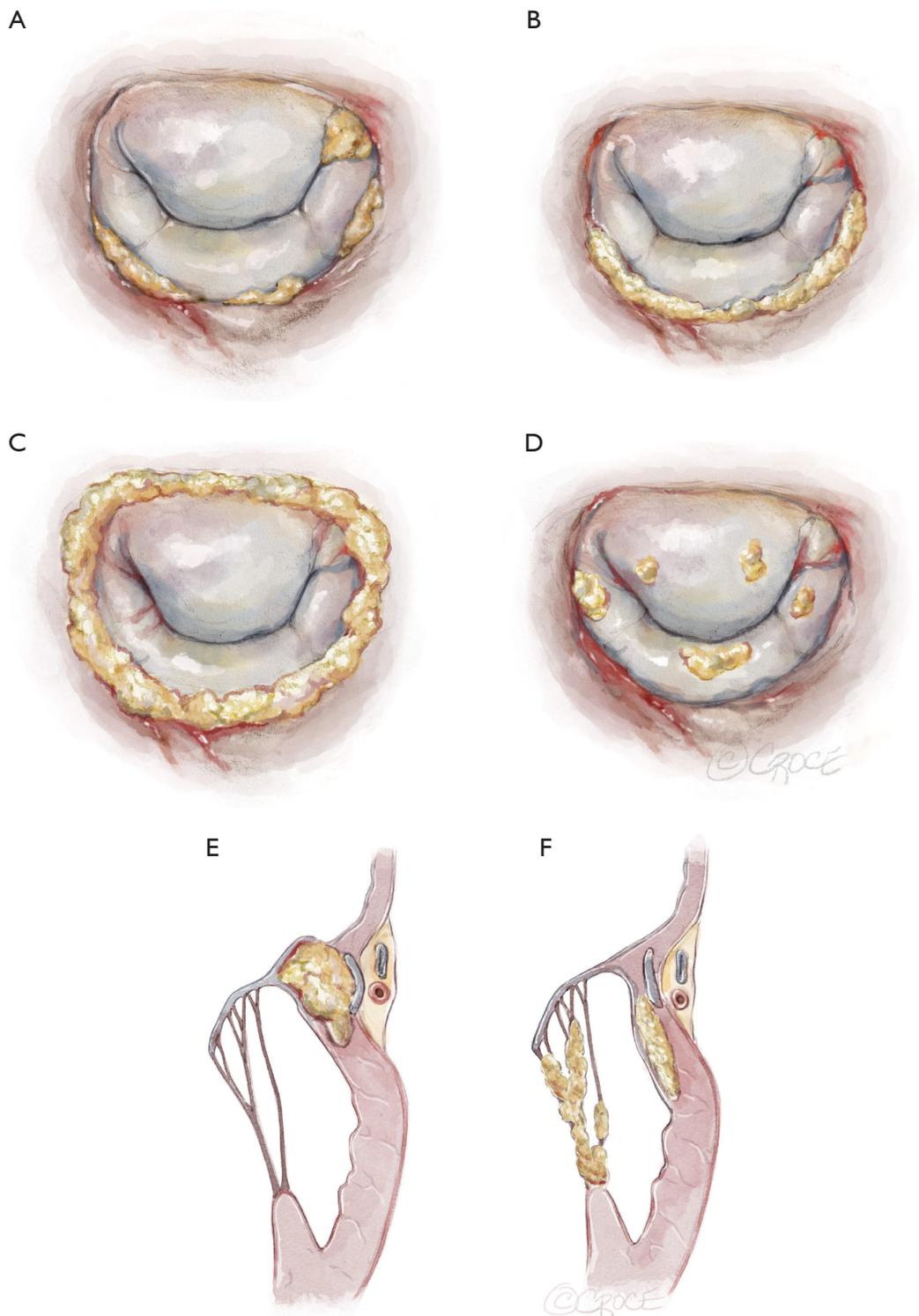


Figure 1 Different degrees and distributions of annular and mitral valve calcifications. (A) Partial posterior annular calcification. In this example, the annulus in the posterior-medial commissural area also shows calcifications. (B) Complete calcification of the posterior mitral annulus. (C) Complete annular calcification. (D) Leaflet calcifications. (E) Sagittal view of annular calcification and its relation to the leaflet and circumflex artery and heart vein. (F) Sagittal view of myocardial calcification and calcification of the sub-valvular apparatus.

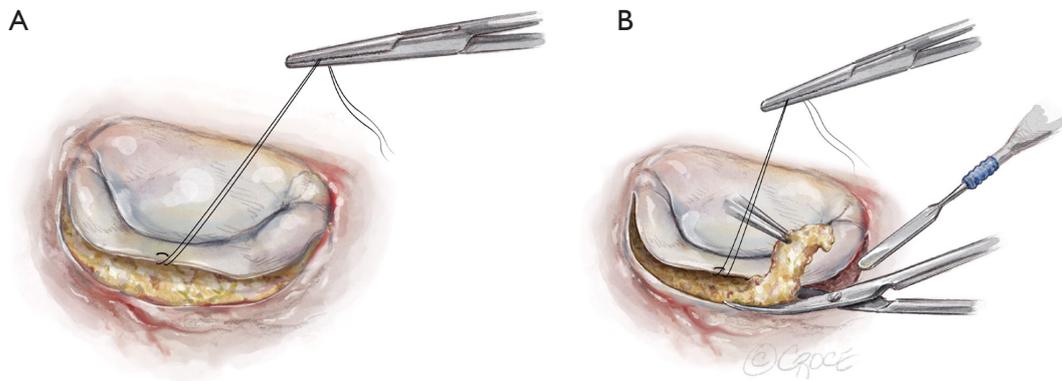


Figure 2 Removal of the posterior calcium bar. (A) Retraction suture on the PML for exposure of the calcium bar. (B) Total resection of the calcium bar. PML, posterior mitral leaflet.

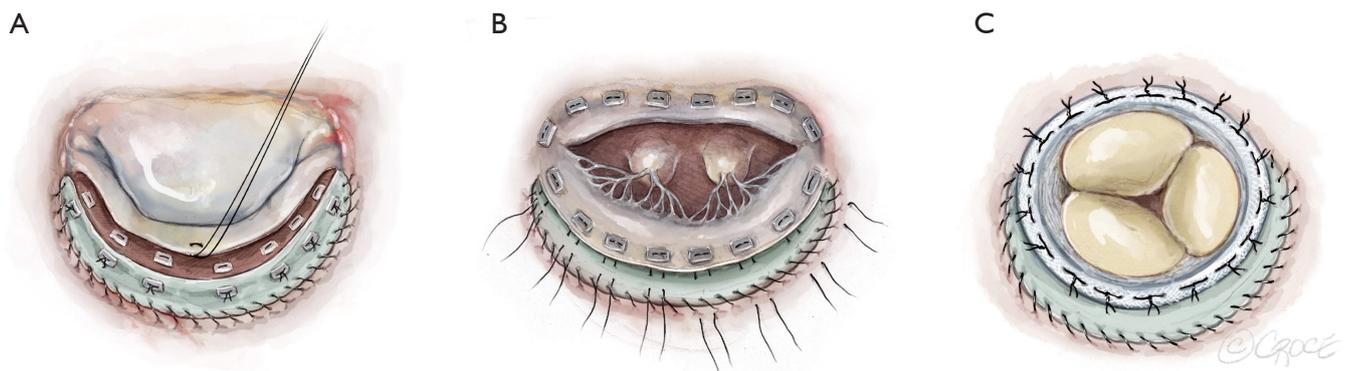


Figure 3 Reconstruction of the posterior annulus with a pericardial patch. (A) Reconstructed posterior annulus using a bovine pericardial patch. Additional pledgeted reinforced U-sutures are placed for reinforcement of the ventricular side. (B) Pledged U-sutures for mitral valve replacement are passed through the preserved posterior leaflet and the patch. (C) Implanted tissue valve.

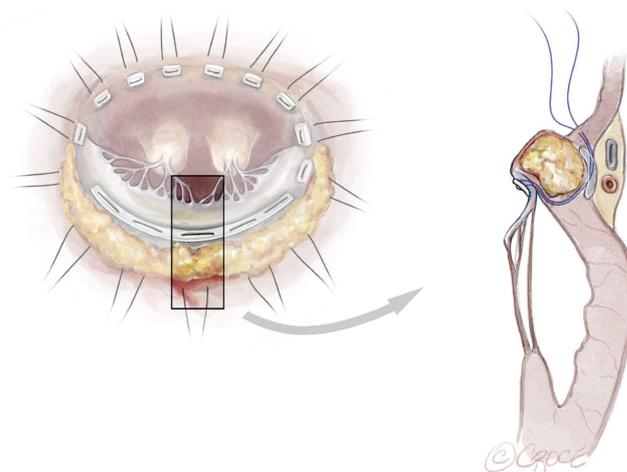


Figure 4 Example of placing posterior annular sutures without removal of the calcium bar. (A) Single 3/0 monofilament U-sutures are passed through a Teflon strip and then under the calcium bar towards the left atrium. (B) Sagittal view of the sutures under the calcium bar.

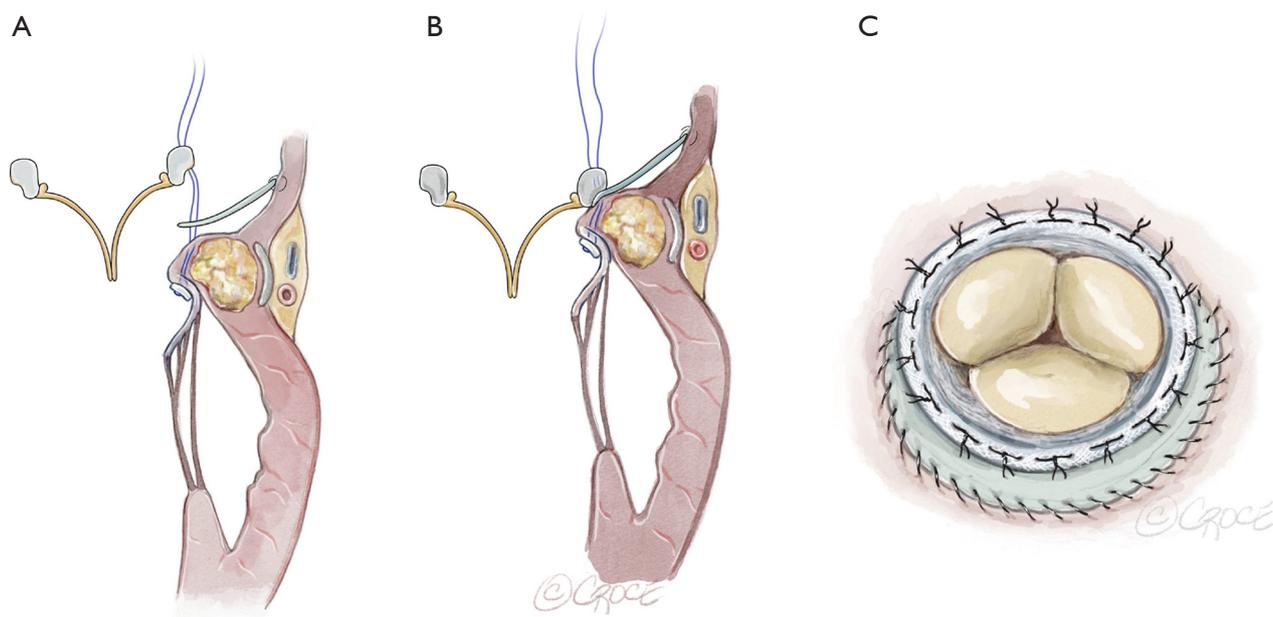


Figure 5 Example of placing posterior annular sutures with pericardial patch reinforcement and without removal of the posterior calcium bar. (A) Sagittal view of pledgeted, reinforced U-sutures, which are passed through the PML, a pericardial patch, and the suture ring of the prosthesis, respectively. (B) The patch is anchored to the left atrial muscle. (C) Final result of the implanted tissue valve. PML, posterior mitral leaflet.

atrial muscle. The U-sutures are finally passed through the valve prosthesis (*Figure 5A*). As the patch is initially loose towards the left atrial side, it is attached and reinforced with shallow stitches in the circumflex area and generous stitches through the left atrial muscle. A continuous 3/0 or 4/0 monofilament suture is used. *Figure 5B* depicts the final result with the valve and patch in place, and *Figure 5C* demonstrates the principle of this technique in a sagittal view.

In the most severe scenario of MAC with involvement of the complete annulus in the calcification and additional thickening and calcification of both leaflets, none of the previously described techniques may be feasible. In this case, a transatrial implantation of a transcatheter heart valve (THV) may be the only option. To accommodate a reasonably sized prosthesis, as much resection of the AML and PML is performed as possible. Multiple reinforced U-sutures are then placed through all areas, where sutures are able to pass through the calcium, underneath the calcium, or through the remaining leaflets, without potential mobilization of the calcium (*Figure 6A*). After balloon sizing, the THV (usually a standard Edwards Sapien valve) is prepared. A 10 mm in width soft Teflon strip is sutured to the base of the THV with a running 5/0 monofilament

suture (*Figure 6B*). Following crimping of the valve in an inverted fashion with the catheter delivery system or in a non-inverted fashion by using the transthoracic (Certitude) delivery system, the locations of the valve commissures are marked with a marking pen for adequate valve alignment in relation to the left ventricular outflow tract. Under direct vision, the THV is slowly deployed. Position should be 3–4 mm atrially, which corresponds to being positioned 20% atrial and 80% ventricular. Anchoring sutures are then passed through the Teflon strip and valve frame and tied (*Figure 6C*). The THV is finally ballooned again (*Figure 6D*).

Following the final assessment of the mitral valve repair/replacement and exclusion of any potential residual paravalvular leakage, operations are completed in a standard fashion. Closure of the atriotomy, weaning from cardio-pulmonary bypass, and chest closure follow the surgical access used. Detailed assessment of mitral valve or prosthetic valve performance is evaluated by transesophageal echocardiography at the end of the procedure.

Comments

MAC is a progressive, age-dependent process associated

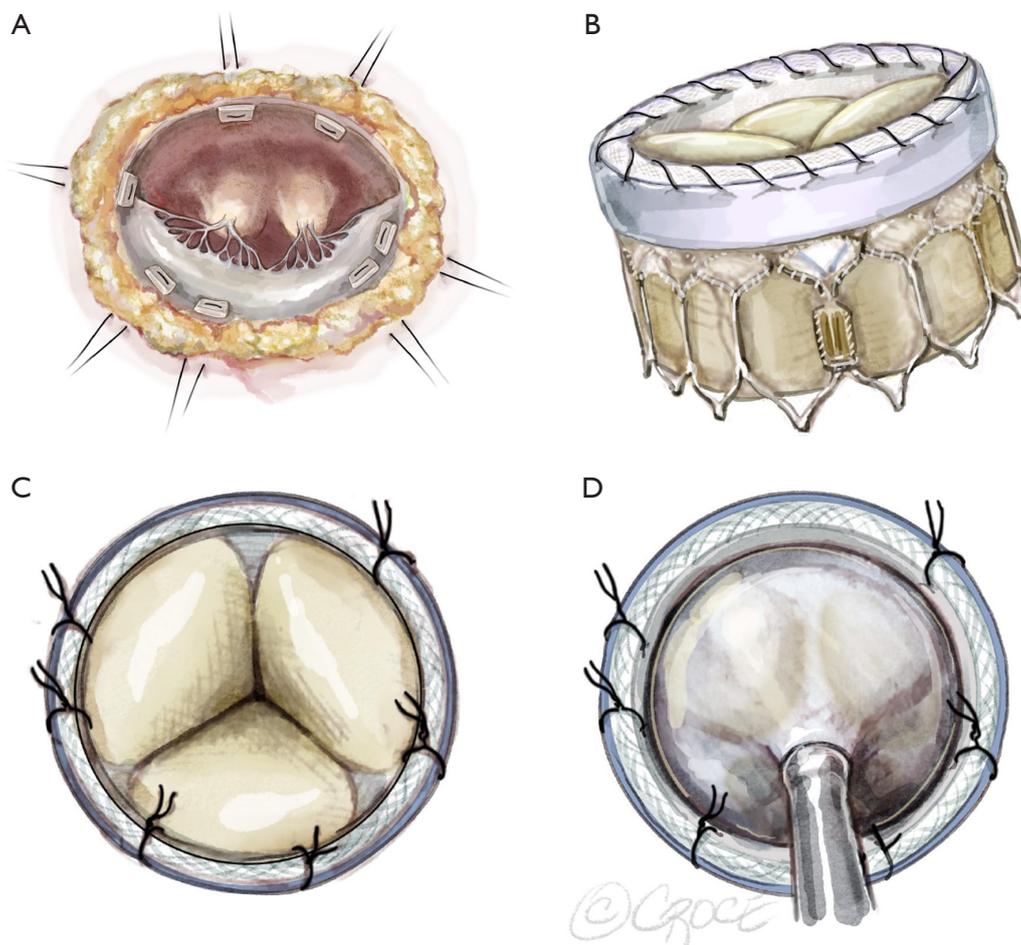


Figure 6 Surgical implantation of a transcatheter heart valve. (A) Complete resection of the AML. Multiple pledgeted U-sutures are placed through the annulus and/or the calcium, wherever possible. (B) A 10 mm in width Teflon strip is sutured to the base of a THV. (C) The THV is implanted under direct vision in an appropriate position with regard to the commissures. Annular sutures are passed through the Teflon strip of the THV and tied. (D) The THV is finally ballooned. AML, anterior mitral leaflet; THV, transcatheter heart valve.

with common cardiovascular risk factors and a variety of other conditions, including chronic inflammatory states, connective tissue diseases, and infective endocarditis. It can lead to mitral valve malfunction, necessitating surgical or interventional treatment. Surgery can be challenging due to the potential risks of atrioventricular dehiscence, circumflex artery injury, and paravalvular leakage.

A variety of surgical techniques have been described. If the posterior annulus is involved, these include complete removal of the calcium bar with patch reconstruction of the posterior mitral annulus (4,12). Modifications for anchoring the pericardial patch and/or the valve within the patch have also been presented (13). As the mitral valve is typically replaced in the majority of cases with significant

MAC, secure anchoring of the prosthesis, particularly in the posterior annular area, is essential.

If the calcium bar is not resected, several alternative techniques have been described. When sutures cannot be passed through the calcium bar, reinforced U-sutures can be placed through the PML and the plicated left atrial tissue to create a “new annulus”, as described by Di Stefano and coworkers (14). The AML may be used as a reinforcement or to exclude calcium after it has been detached and transposed to the posterior annulus (15). Pan and colleagues described a double-layer horizontal cross-suture technique for intra-atrial mitral valve implantation (16). For severe MAC, however, a transatrial THV implantation technique has been demonstrated to be a viable alternative (17-19).

Clinical outcomes are often dependent on patient comorbidities. Intraoperatively, it is important to avoid manipulating the heart if the MAC is not resected or after a prosthetic valve has been implanted to prevent atrioventricular rupture. Circumflex artery injury remains an operative risk and should be addressed on a case-by-case basis (e.g., with bypass grafting, immediate postoperative intervention, or medical management).

As the severity of MAC varies, an individualized approach to this pathology is required. The authors' preference is to avoid complete resection of the posterior calcium bar, instead utilizing the described techniques for valve anchoring. In the presence of severe MAC, transatrial THV implantation is the preferred technique.

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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

- Bonninger M. Bluttransfusion bei perniziöser anämie:(b) Zwei Falle von Herzblock. *Dtsch Med Wochenschr* 1908;34:2292.
- Abramowitz Y, Jilaihawi H, Chakravarty T, et al. Mitral Annulus Calcification. *J Am Coll Cardiol* 2015;66:1934-41.
- Kanjanathai S, Nasir K, Katz R, et al. Relationships of mitral annular calcification to cardiovascular risk factors: the Multi-Ethnic Study of Atherosclerosis (MESA). *Atherosclerosis* 2010;213:558-62.
- Carpentier AF, Pellerin M, Fuzellier JF, et al. Extensive calcification of the mitral valve annulus: pathology and surgical management. *J Thorac Cardiovasc Surg* 1996;111:718-30.
- 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.
- 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.
- Benjamin EJ, Plehn JF, D'Agostino RB, et al. Mitral annular calcification and the risk of stroke in an elderly cohort. *N Engl J Med* 1992;327:374-9.
- Carpentier A, Chauvaud S, Fabiani JN, et al. Reconstructive surgery of mitral valve incompetence: ten-year appraisal. *J Thorac Cardiovasc Surg* 1980;79:338-48.
- Massera D, Trivieri MG, Andrews JPM, et al. Disease Activity in Mitral Annular Calcification. *Circ Cardiovasc Imaging* 2019;12:e008513.
- Gomel MA, Lee R, Grande-Allen KJ. Comparing the Role of Mechanical Forces in Vascular and Valvular Calcification Progression. *Front Cardiovasc Med* 2018;5:197.
- Xu B, Kocyigit D, Wang TKM, et al. Mitral annular calcification and valvular dysfunction: multimodality imaging evaluation, grading, and management. *Eur Heart J Cardiovasc Imaging* 2022;23:e111-22.
- Mihaljevic T, Koprivanac M, Kelava M, et al. Mitral valve replacement in patients with severely calcified mitral valve annulus: surgical technique. *J Thorac Cardiovasc Surg* 2013;146:233-5.
- Uchimuro T, Fukui T, Shimizu A, et al. Mitral Valve Surgery in Patients With Severe Mitral Annular Calcification. *Ann Thorac Surg* 2016;101:889-95.
- Di Stefano S, López J, Flórez S, et al. Building a new annulus: a technique for mitral valve replacement in heavily calcified annulus. *Ann Thorac Surg* 2009;87:1625-7.
- Elde S, Zhu Y, MacArthur JW, et al. Surgical management of severe mitral annular calcification. *Asian Cardiovasc Thorac Ann* 2023;31:297-302.
- Pan Y, Zhou Y, Liu Y, et al. Double-layer horizontal cross sutures for intra-atrial mitral valve implantation: An effective surgical method for severe mitral annular calcification. *JTCVS Tech* 2023;22:28-38.
- Praz F, Khalique OK, Lee R, et al. Transatrial implantation of a transcatheter heart valve for severe mitral annular

- calcification. *J Thorac Cardiovasc Surg* 2018;156:132-42.
18. 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.
 19. Toubat O, Shin M, Atluri P. Surgical or transcatheter mitral valve replacement with mitral annular calcification. *JTCVS Struct Endovasc* 2024;1:100011.

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