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REVIEW ARTICLE

# Mitral Valve Repair of the Anterior Leaflet: Are We There Yet?

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## ABSTRACT

Mitral regurgitation is one of the most prevalent valvulopathies with a disease burden that incurs significant healthcare costs globally. Surgical repair of the posterior mitral valve leaflet is a standard treatment, but approaches for repairing the anterior mitral valve leaflet are not widely established. Since anterior leaflet involvement is less common and more difficult to repair, fewer studies have investigated its natural history and treatment options. In this review, we discuss surgical techniques for repairing the anterior leaflet and their outcomes, including survival, reoperation, and recurrence of regurgitation. We show that most patients with mitral regurgitation from the anterior leaflet can be repaired with good outcomes if performed at centers with expertise. Additionally, equal consideration for early repair should be given to patients with mitral regurgitation from both anterior and posterior pathology. However, more studies to better evaluate the efficacy and safety of anterior mitral valve leaflet repair are needed. (Hellenic Journal of Cardiology 2024;78:72-83)
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## 1. INTRODUCTION

Mitral regurgitation (MR) is one of the most prevalent valvulopathies worldwide and was responsible for 34,000 deaths and 0.88 million disability-adjusted life years (DALY) in 2019.[1] In the past few decades, the prevalence of degenerative MR has risen by 70%, primarily in developing countries.[2] The therapy goal

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in severe, degenerative MR is to restore valve function before left ventricular dilation and heart failure occur.[3] For myxomatous disease, the most common type of degenerative MR, surgical repair of posterior leaflet prolapse is the standard surgery of choice with superior outcomes compared to replacement of the valve with a prosthesis.[4] Approaches for repairing the anterior leaflet, however, are far more variable, complex, and overall considered to be less durable.[5] These challenges are partly explained by the fact that the anterior leaflet tissue has less redundancy than its posterior counterpart,[6] making anterior leaflet repair a more technically challenging option. Furthermore, studies on anterior leaflet repair have been limited so far. There is no randomized, head-to-head comparison of surgical repair of the anterior leaflet vs. valve replacement, and most observational studies review the clinical outcomes of replacement with the full spectrum of leaflet repair rather than isolated anterior mitral leaflet repair.[7] In this review, we aim to provide a review of the literature on surgical repair of the anterior mitral leaflet. Specifically, we discuss current surgical techniques and outcomes of anterior leaflet repair in degenerative MR.

## 2. SURGICAL ANATOMY AND ANTERIOR LEAFLET DISEASE

The normal mitral valve consists of an anterior and a posterior leaflet. The posterior leaflet is crescentic with a shorter radial length and a longer circumferential base compared to the anterior leaflet. It is divided into lateral (P1), central (P2), and medial (P3) scallops, with indentations in between. The anterior leaflet is trapezoid-shaped and substantially longer than the posterior leaflet; it has a fibrous continuity with the left and non-coronary aortic valve cusps (aorto-mitral curtain) and is divided arbitrarily into A1, A2, and A3 (lateral to medial) scallops corresponding to the posterior leaflet scallops.[8]

Redundant leaflet tissue is crucial for adequate coaptation and sealing.[9] The preservation of normal leaflet stress depends on the elliptical and saddle-shaped nature of the normal mitral annulus.[10]

Degenerative MR is caused by primary leaflet pathology with the most common type being mitral valve prolapse (MVP), which affects 2% to 3% of the global population.[11] MVP is characterized by excessive tissue or increased extensibility of the leaflets, leading to inadequate closure and chronic MR. It can also lead to chordal rupture and acute MR due to flail leaflet. The extent and severity of MVP can vary, ranging from involvement of a single segment to all segments of both leaflets.[12] A meta-analysis of 23 studies and 6,565 patients found that isolated posterior leaflet prolapse accounts for 51% of cases, whereas the anterior leaflet is involved in 49% of cases, either isolated (24%) or together with the posterior leaflet (25%).[12]

## 3. REVIEW OF SURGICAL TECHNIQUES FOR ANTERIOR LEAFLET REPAIR

The primary objective of surgical repair in degenerative MR is to eliminate MR in an efficient and durable way by maintaining as much native tissue as possible without the need for a valve prosthesis. Compared to the posterior leaflet, surgical repair of anterior leaflet prolapse is a more complex surgical task. There are currently various repair techniques available, with variable success rates.[13] Below, we present the most important techniques, followed by a section on minimally invasive approaches. In general, the choice of repair method depends on several factors, including the degree of prolapse, the type of lesions present (such as chordae elongation or rupture), and the surgeon's level of expertise. In some cases, multiple repair methods may be necessary to achieve optimal valve function. Also, repair of myxomatous degeneration is more complicated than fibroelastic deficiency and usually requires a combination of techniques.

**3.1. TRIANGULAR RESECTION.** Similar to the posterior leaflet, triangular resection of the anterior leaflet refers to excising a triangular-shaped piece of redundant tissue that has its base at the prolapsing portion's free edge and its apex close to the annulus. Running or interrupted sutures without patch utilization are used to restore leaflet continuity, and an annuloplasty band or ring may complete the surgery (**Fig. 1**). The idea behind triangular excision is to make the process simpler by doing away with annular plication and to avoid leaving a segment of pathological tissue that might cause excessive scarring and subsequent fibrous proliferation or leaflet retraction. Identifying the normal chordae on either side of the prolapsing segment can assess how much resection is necessary.[13] It is important to note that while quadrangular resection is a common strategy in treating posterior leaflet prolapse, it is not used for anterior leaflet prolapse repair as triangular resection has been associated with fewer complications.[13]

**3.2. PATCH REPAIR OF THE ANTERIOR LEAFLET.** An autologous pericardial patch can be used to repair the anterior mitral valve leaflet. Although this is not a preferred technique for MVP, it can be used in cases of endocarditis (**Fig. 2**).[14] Frequently, the repair can be done through the aortotomy during aortic valve intervention.[6]

**FIGURE 1** **Triangular resection of anterior MVP**

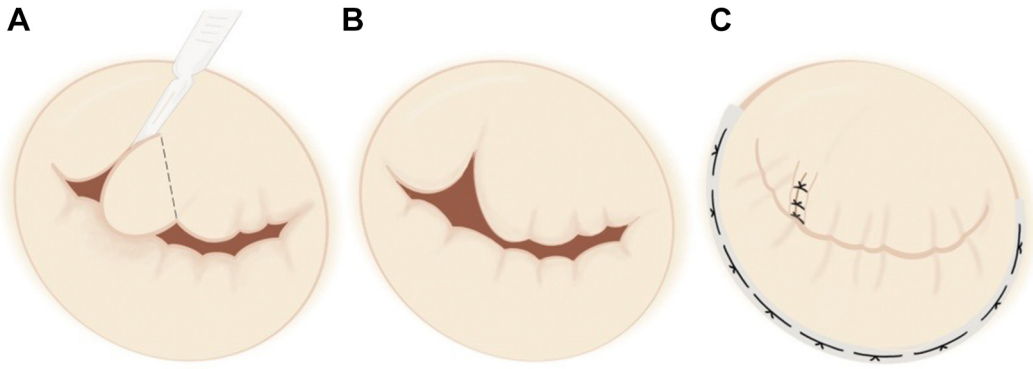



**FIGURE 2** **Anterior mitral valve leaflet patch augmentation with annuloplasty**

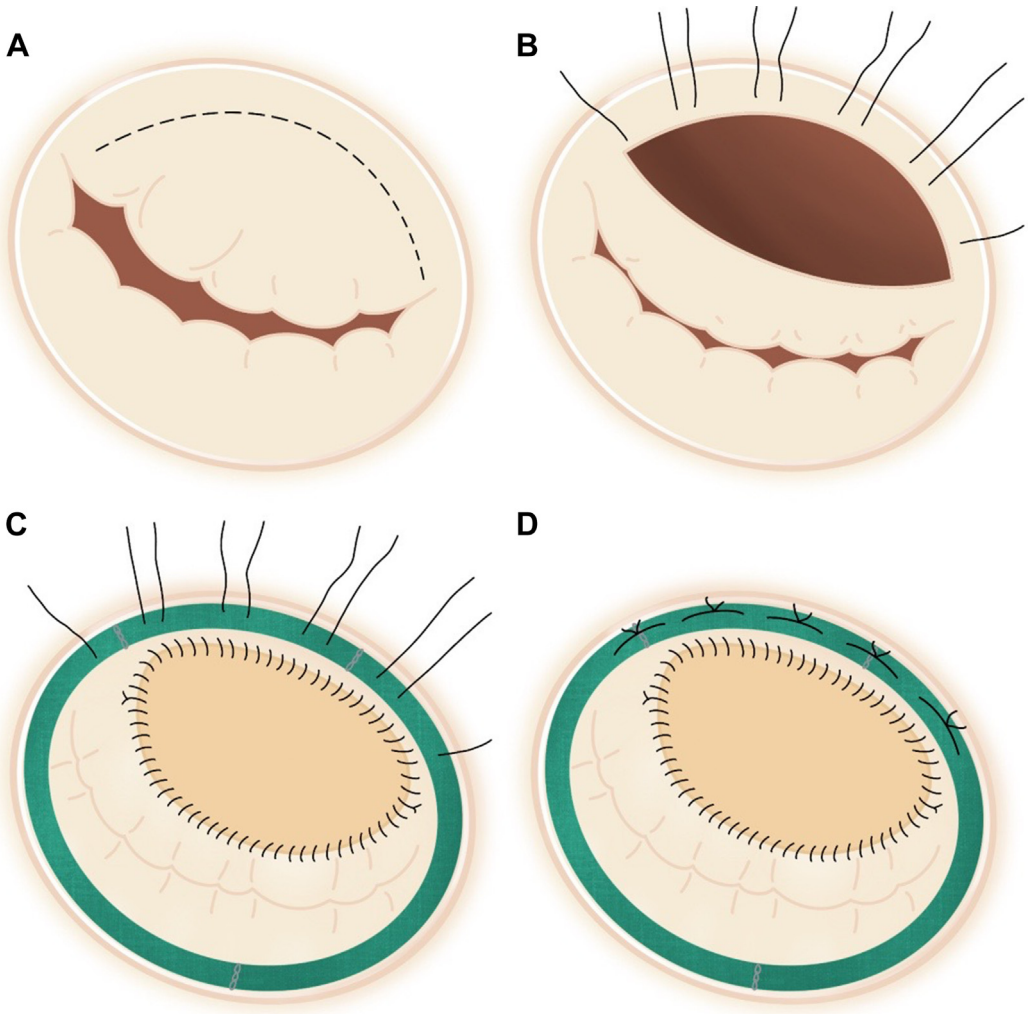
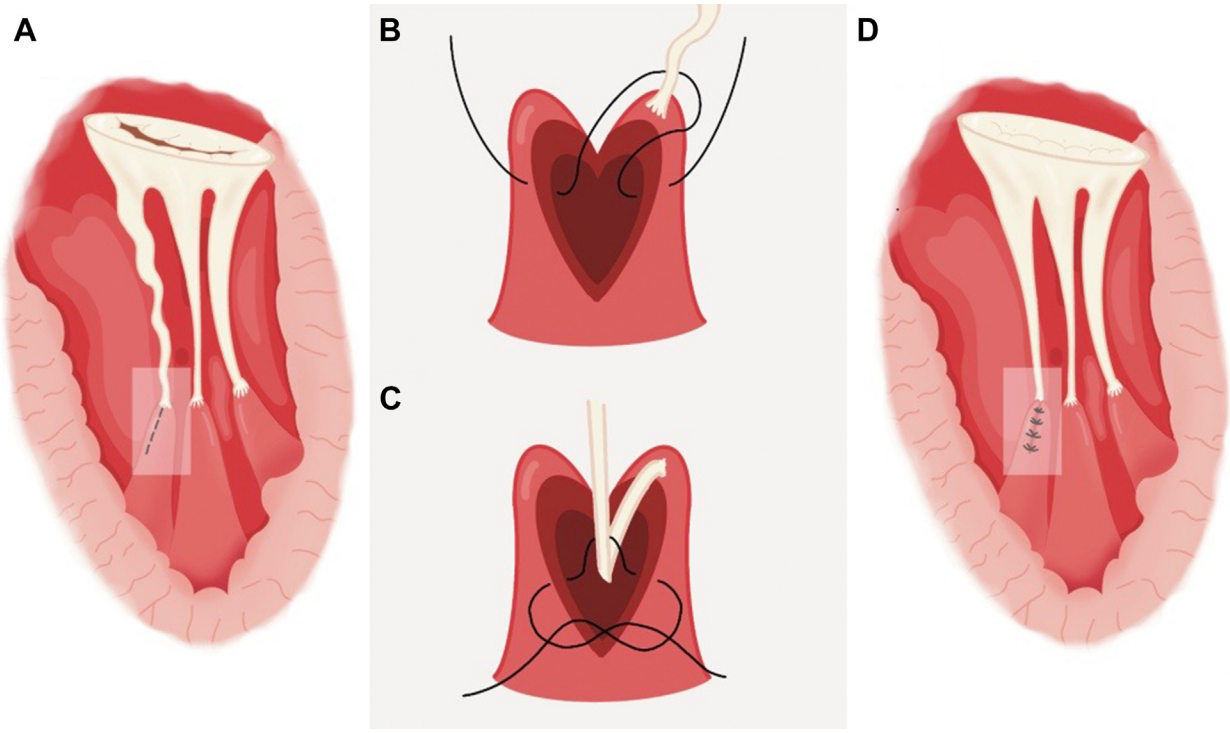


**FIGURE 3** **Chordae shortening**




**3.3. CHORDAL SHORTENING.** To shorten elongated chordae, surgeons often use a technique that involves plicating the distal end of the chordae under the free edge or burying the extra length into the papillary muscle next to the chordae's origin (Fig. 3).[15]

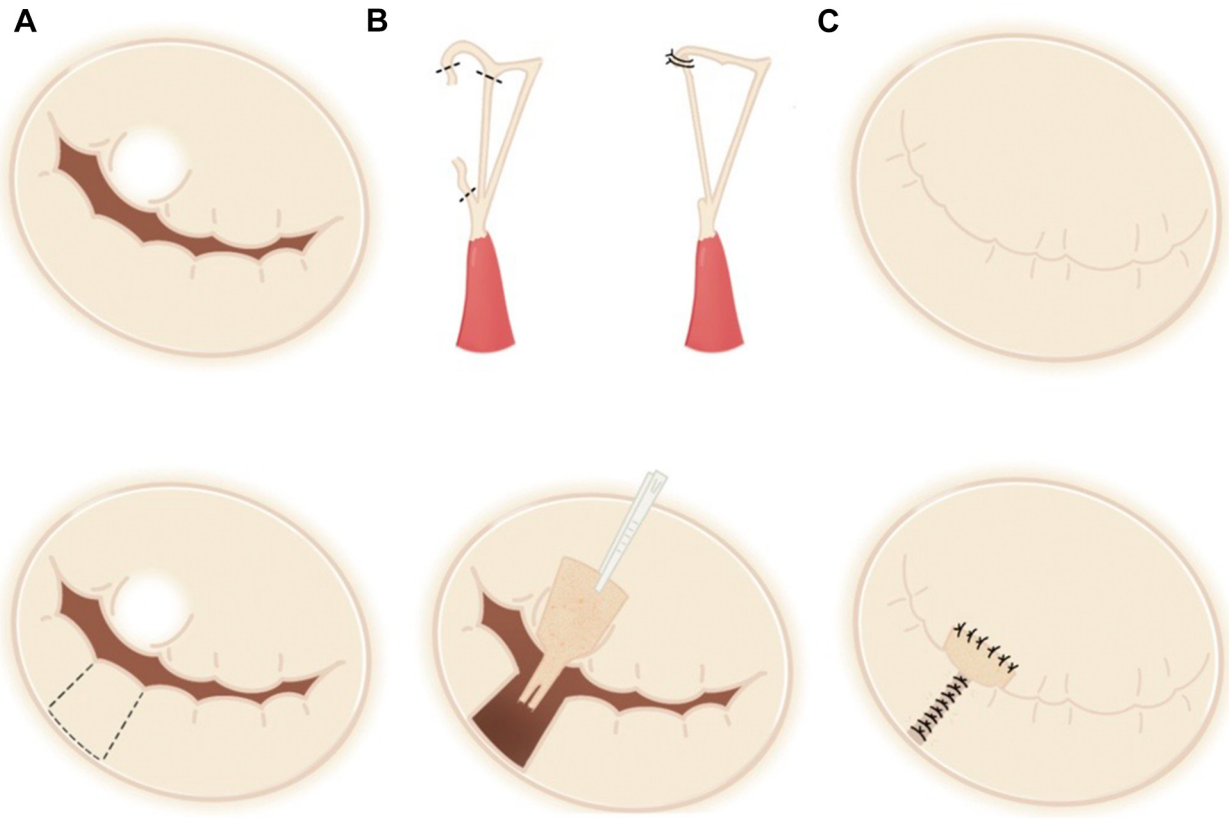
**3.4. CHORDAL TRANSFER.** Patients with anterior leaflet prolapse secondary to chordal rupture (flail) or chordae elongation can be treated with chordal transfer.[16] It is feasible to transpose normal chordae from the posterior leaflet to the anterior leaflet or secondary chordae from the anterior leaflet to the free prolapsing edge. Transferred chordae in both scenarios will be fitted in length (Fig. 4).[17]

**3.5. NEO-CHORDAE IMPLANTATION.** In 1984, Herbert Vetter showed that expanded polytetrafluoroethylene (ePTFE) sutures developed neo-fibrosa and neo-intima, and Tirone David started using this material for replacing chordae tendinea. Soon after, a new era in mitral valve repair started.[18] Neo-chordae can either be free-hand chordae or pre-measured chordal loops and are used to treat prolapse by supporting the leaflet's free border and creating the best possible surface for coaptation.[13] To use this technique effectively, it is important to identify the appropriate length of the artificial chordae. Different modalities have been proposed to establish the proper length of the new chordae, which can be categorized as functional and anatomic.[19] For anterior leaflet prolapse, the flail part is not usually elongated (unlike the posterior prolapse); thus, the longitude of anterior neo-chordae loops is equivalent to the length from corresponding papillary head to the coaptation area. Following the neo-chordae implantation, a ring annuloplasty can be performed. This technique can be placed in a variety of access settings, including open surgery, minimally invasive, and robotic-assisted repair (Fig. 5).[20, 21]

**3.6. PAPILLARY MUSCLE REPOSITIONING.** Dreyfus et al. first outlined papillary muscle repositioning technique as a rapid surgical method in 2001.[22] The concept behind the method involves connecting one head of the papillary muscle that supports elongated chordae to a neighboring head at a lower position (Fig. 6).[17] The anterior papillary muscle generally has 2 heads (anterior and posterior), whereas the posterior papillary muscle has 3 (anterior, intermediate, and posterior).

**3.7. EDGE-TO-EDGE REPAIR.** Alfieri et al. proposed the edge-to-edge technique in 1991. The prolapsing leaflet's free edge is anchored to the matching free edge of the leaflet on the other side, thus creating a double orifice valve with a reduction of the

**FIGURE 4** Repair of anterior mitral leaflet prolapse by secondary chordal transferring from the posterior leaflet to the free edge of the anterior leaflet




regurgitant orifice.[13] Severe MR caused by segmental prolapse of the anterior leaflet affecting only one scallop is an excellent indication for this technique.[23]

**3.8. MINIMALLY INVASIVE APPROACHES FOR ANTERIOR LEAFLET REPAIR.** The main advantages of minimally invasive cardiothoracic surgery (MICS) approaches are avoidance of sternotomy and shorter length of stay in the intensive unit and hospital despite longer cardiopulmonary bypass time. On the other hand, MICS requires additional expertise in order to achieve similar outcomes to conventional MV surgery.[24-27] Almost all repair techniques described can be performed via MICS, so much so that choosing between MICS or conventional surgery depends more on the surgeon's preference and expertise rather than on leaflet pathology. Partial sternotomy, mini-thoracotomy, and robotic surgery fall under this category.

**3.8.1. Thoracoscopic and port access.** The port access system enables a minimally invasive approach to repairing the mitral valve through a small incision in the side of the chest, with assistance of video technology,[28] and can be utilized for both posterior and anterior leaflet repair. This method is safe and has good early results when carried out by skilled surgeons.[29]

**3.8.2. Robotic-assisted mitral valve repair.** The robotic method offers better visualization compared to other minimally invasive techniques and the ability to make precise movements through the robotic console.[30] PTFE (Gore-Tex) with neo-chord resuspension is one of the most common techniques that can be performed robotically to treat anterior leaflet prolapse.[6]

## 4. OUTCOMES OF ANTERIOR REPAIR

Table 1 summarizes the studies and outcomes of patients with degenerative MR who underwent surgical repair of the anterior leaflet, either isolated or in conjunction with posterior leaflet repair (bileaflet repair). Studies including rheumatic heart disease patients were excluded.

11 retrospective studies were identified with a total of 1664 patients included. Mean age ranged from

32.4 ± 7.68 to 63.2 ± 9.6 years. Mean follow-up time ranged from 24 to 138 months. All studies included patients with isolated anterior leaflet repair. Patients with bileaflet repair were present only in 2/11 studies. In-hospital mortality and long-term survival in the studies with bileaflet repair were 0 and 88%, respectively.[24, 31] Multiple surgical techniques for anterior leaflet repair were used in the majority of studies (45.4%).

For isolated anterior leaflet repair, in-hospital mortality ranged from 0 to 4.8%. However, in-hospital mortality was less than 2% for 9 out of 11 studies. In the study with the largest cohort including 309 patients with isolated anterior MR, a variety of techniques were used, and in-hospital mortality was only 1%.[27] The highest in-hospital mortality was noted when multiple techniques (chordae transfer: 45.5% and neo-chordae replacement: 43.5%) were used in a study with less than 50 patients with isolated anterior MR.[31] 5-year survival ranged from 86.7% to 96.6% and was highest when extensive subvalvular debridement, over-commissurotomy, and papillary muscle splitting were used.[32]

In terms of efficacy, the rate of moderate to severe MR ranged from 0% to 12.5% at long-term follow-up. Most durable results (i.e., lowest rate of moderate or more MR at follow up) were seen with utilization of multiple techniques.[27, 33] The highest rate of reoperations for recurrent or persistent MR was 10.4% and was seen when the edge-to-edge technique was performed.[34] Nisivaco et al. showed that repairing complex anterior leaflet prolapse can be accomplished successfully by using different methods without the need for neo-chord implantation. Thus, there are alternative approaches to repairing intricate valves that do not require the expertise and decision-making of neo-chord repair.[24] Long-term freedom from moderate to severe MR and freedom from reoperation after bileaflet repair ranged from 91.8% to 97.7% and from 94.1% to 97.6%, respectively.

**FIGURE 5** **Artificial chordae for mitral valve repair**

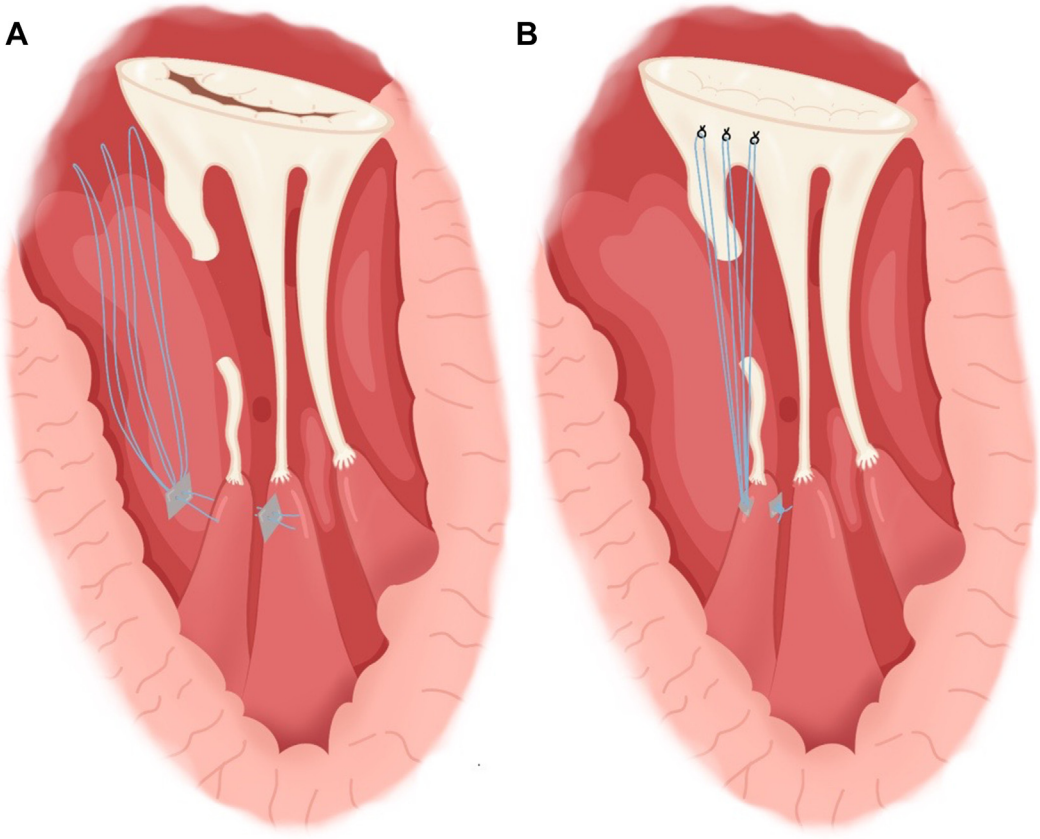
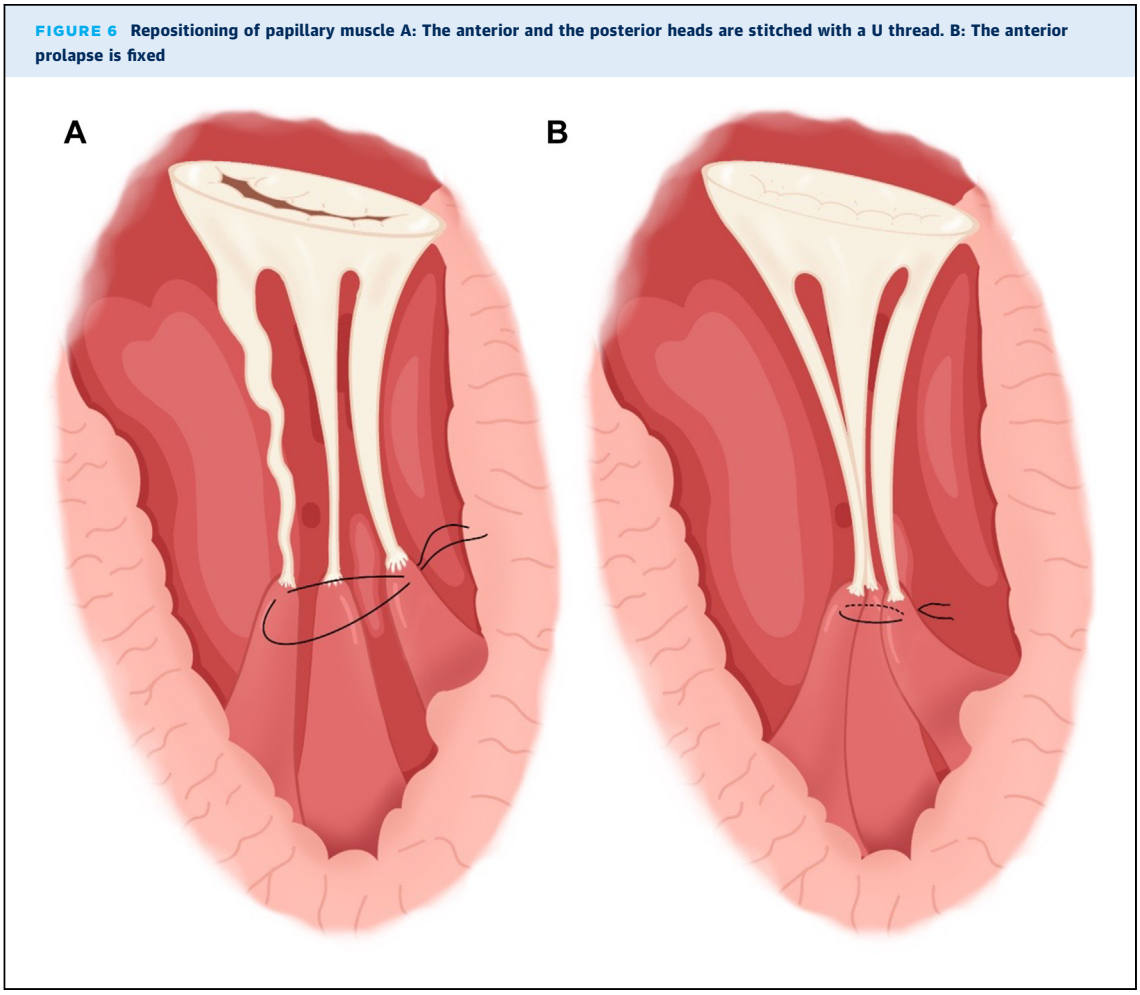


**FIGURE 6** **Repositioning of papillary muscle A: The anterior and the posterior heads are stitched with a U thread. B: The anterior prolapse is fixed**




## 5. COMPARISON OF OUTCOMES WITH ISOLATED POSTERIOR LEAFLET REPAIR AND VALVE REPLACEMENT

Table 2 summarizes studies that compared anterior repair with isolated posterior repair or valve replacement for degenerative MR. Six studies met search criteria and were included in the analysis. All studies were retrospective and were published between 2005 and 2019.

**5.1. COMPARISON OF ANTERIOR VERSUS POSTERIOR REPAIR.** Five studies compared anterior with isolated posterior leaflet repair. A total number of 5594 patients were included; 577 patients underwent isolated anterior repair, and 588 patients underwent bileaflet repair. Two studies compared isolated anterior repair with isolated posterior repair. The rest of the studies compared isolated anterior and bileaflet repair with isolated posterior repair.

In 3 of the 5 studies, multiple surgical techniques were used for anterior repair, with neo-chordae implantation being the most common. The most common surgical technique for posterior repair was leaflet resection. Inpatient mortality, 5-year survival, 10-year survival, and freedom from moderate to severe MR re-occurrence among all studies ranged from 0-1%, 90-99.1%, 72-91%, and 89-99%, respectively, for isolated anterior leaflet repair and 0-1%, 88-97.7%, 74-93.5%, and 89-100%, respectively, for isolated posterior leaflet repair. Results for bileaflet repair were not separately reported.[27, 41, 42]

In the study with the largest group of patients undergoing anterior leaflet repair, in-hospital mortality and 10-year survival were similar between isolated posterior leaflet repair and repair that included the anterior leaflet, after propensity score matching. Of note, the majority of anterior leaflet repair (72.4%) involved the posterior leaflet as well. A slightly higher rate of reoperation per patient-year in the anterior

**TABLE 1** Outcomes of studies on surgical repair of the anterior mitral valve leaflet

| First author | year | Total number | Isolated anterior/ Bileaflet | Surgical technique | Inpatient/short term mortality | Long-term survival | Rate of reoperation | MR recurrence (Grade at last follow-up examination) |
|---|---|---|---|---|---|---|---|---|
| **Nisivaco**[24] | 2023 | 343 | Isolated anterior: 83/ Bileaflet: 260 | Chordal transfer, commissuroplasty, and edge-to-edge repair | 30-day mortality: Isolated anterior: 0 / Bileaflet: 0 | 1-year: isolated anterior: 100% / bileaflet: 99.6%, 5-year: isolated anterior: 96.6% / bileaflet: 96.2%, 10-year: isolated anterior: 78% / bileaflet: 88.9% | Freedom from reoperation: 10-year: isolated anterior: 100% / bileaflet: 97.6% | Freedom from moderate or severe MR: 10-year: isolated anterior: 94.5% / bileaflet: 97.7% |
| **Brescia**[27] | 2019 | 309 | Isolated anterior | Multiple techniques | In-hospital: 1% | 5-years: 90% ± 4%; 10-years: 72% ± 7%; 15-years: 63% ± 7% | 0.74% per patient-year | Post procedure: None: 92%, Mild: 3%, Moderate: 0%, Severe: 0%, Missing: 4% |
| **Kadirogullari**[35] | 2018 | 125 | Isolated anterior | Multiple techniques | Intraoperative: 0 Early: 0.8% | Late: 1.6% | 3.2% (4 patients) At a mean follow-up period of 24.4 ± 16.8 months | None: 88.8%, Mild: 3.2%, Moderate: 3.2%, Severe: 4% |
| **Maeda**[36] | 2018 | 38 | Isolated anterior | Chordal replacement | In-hospital: 3% | 5-year: 95% ± 4% | 5-year freedom from reoperation: 96% ± 4% | 5-year freedom from recurrent MR: 94% ± 4% |
| **Castillo**[31] | 2014 | 188 | Isolated anterior: 42/ Bileaflet: 146 | Multiple techniques | In-hospital: Isolated anterior: 4.8% / Bileaflet: 0 | 1-year: isolated anterior: 97.5% / bileaflet: 98.6%, 4-year: isolated anterior: 86.2% / bileaflet: 96.3%, 7-year: isolated anterior: 86.2% / bileaflet: 88.6% | 7-year freedom from reoperation for all patients: 94.1% ± 0.5% | Freedom from ≥moderate MR: 1-year: isolated anterior: 96.9% / bileaflet: 100%, 4-year: isolated anterior: 90.4% / bileaflet: 98.8%, 7-year: isolated anterior: 80.4% / bileaflet: 91.8% |
| **Bonis**[34] | 2014 | 139 | Isolated anterior | Edge-to-edge repair | In-hospital: 0 | 17-year: 72.4% ± 7.89% | Freedom from reoperation: 89.6% ± 2.74% | Recurrence of MR grade >3+: 12.5% Freedom from MR grade >3+ at 17 years: 80.2% ± 5.86% |
| **Pfannmuller**[37] | 2012 | 180 | Isolated anterior | Multiple techniques | 30-day: 1.8% | 5-year: 86.7% ± 3.2% | 5-year freedom from reoperation: 95.7% ± 1.6% | N/A |
| **Zhang**[38] | 2010 | 21 | Isolated anterior | Edge-to-edge repair | Early: 0% | Late mortality rate: 0% | 4.7% | N/A |
| **Morimoto**[33] | 2008 | 49 | Isolated anterior | Multiple techniques | In-hospital: 0 | 10-year: 95.2% 15-year: 88.9% | freedom from reoperation: 10-year: 95.8% 15-year: 89.0% | trivial: 17 (34.7%), Mild: 7 (14.3%), Moderate: 0, Severe: 0 |
| **Fucci**[39] | 2007 | 68 | Isolated anterior | Edge-to-edge repair | Intraoperative: 0 in-hospital: 1.4% | 13-year: 90% ± 1.4% | early: 0 late: 5.8% 13-year freedom from reoperation: 92.3% ± 3.2% | Of the remaining 60 patients: Non: 66.66% Trivial: 30% Mild: 3.33% |
| **Kasegawa**[40] | 2006 | 204 | Isolated anterior | chordal replacement with ePTFE sutures | 30-day mortality: 1.9% | 12-year: 84.6% ± 4.0% | 2.2%/patient-years freedom from reoperation: 12-year: 89.9% ± 2.9% | mild or less: 87.1% 12-year freedom from severe MR: 88.1% ± 3.1% |

Abbreviations: MR: mitral regurgitation, PTFE: Polytetrafluoroethylene, N/A: not available.

**TABLE 2** Anterior repair vs. posterior repair or replacement

| First author | year | AL group size | Anterior repair technique | PL or replace group size | Posterior repair technique or type of prostheses | Mortality | | Efficacy: MR recurrence | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Anterior repair | PL repair or replacement | Anterior repair | PL repair or replacement |
| **Alexander A. Brescia**[27] | 2019 | 309<br>AL: 85<br>BL: 224 | Multiple techniques | PL: 309 | - | In-hospital mortality: (1%) 3/309<br>5-year survival: 90% ± 4%<br>10-year survival: 72% ± 7%<br>15-year survival: 63% ± 7% | In-hospital mortality: 3/309(1%)<br>5-year survival: 88% ± 5%<br>10-year survival: 74% ± 7%<br>15-year survival: 60% ± 8% | None: 280 (92%)<br>Mild: 10 (3%)<br>Mod: 1 (0%)<br>Severe: 0<br>Missing: 13 (4%) | None: 289 (94%)<br>Mild: 8 (3%)<br>Mod: 1 (0%)<br>Severe: 0<br>Missing: 9 (3%) |
| **Eilon Ram**[42] | 2019 | 285<br>AL: 52<br>BL: 233 | Artificial chordae implantation | PL: 485 | Posterior leaflet resection | No operative mortalities,<br>1-year survival: BL: 100%, AL: 98.1%,<br>5-year survival: BL: 98.2%, AL: 98.1% | No operative mortalities,<br>1-year survival: 99.6%,<br>5-year survival: 97.7% | Freedom from mod-severe MR:<br>BL: 97%<br>AL: 96% | Freedom from mod-severe MR: 94% |
| **Spiegelstein**[41] | 2013 | 131 AL and BL | Multiple techniques | PL: 276 | Multiple techniques | Hospital mortality: AL/BL: 0 (0%)<br>Late mortality: AL/BL: 3 (2%)<br>5-year survival: AL/BL: 99% ± 1% | Hospital mortality: 1 (0.4%)<br>Late mortality: 3 (1%)<br>5-year survival: 97% ± 2% | Freedom from mod-severe MR: AL/BL: 123 (94%), None/trivial: AL/BL: 60 (46%), Mild: AL/BL: 63 (48%), Mod: AL/BL: 5 (4%), Severe: AL/BL: 3 (2%) | Freedom from mod-severe MR: 245 (89%), None/trivial: 105 (38%), Mild: 140 (51%), Mod: 27 (10%), Severe: 3 (1%) |
| **A. Marc Gillinov**[7] | 2008 | AL: 307 | Multiple techniques | PL: 2754 | - | Unadjusted 10-year survival: 83% | Unadjusted 10-year survival: 88% | Mod-severe MR: 11% | Mod-severe MR: 4% |
| **Michele De Bonis**[43] | 2005 | AL: 133 | Edge-to-edge repair | PL: 605 | Quadrangular resection | In-hospital mortality: 0%<br>10-year survival: 91% ± 4.06% | In-hospital mortality: 2 (0.3%)<br>10-year survival: 93.5% ± 1.81% | Severity of MR<br>None: 52 (39%), trivial: 68 (51.1%), Mild: 10 (7.5%), Mod: 0, Severe: 3 (2.2%) | Severity of MR<br>None: 65 (37.7%), trivial: 92 (53.4%), Mild 15 (8.7%), Mod: 0, Severe: 0 |
| **Gonçalo F. Coutinho**[25] | 2016 | 475 AL and BL | Multiple techniques | Replace: 26 | N/A | 30-day mortality: 1.2%<br>1-year survival: 96.2% ± 1.3%<br>5-year survival: 86.5% ± 2.4%<br>10-year survival: 66.3% ± 4.1%<br>20-year survival: 43.4% ± 5.5% | 30-day mortality: 1.8%<br>1-year survival: 80% ± 8.9%<br>5-year survival: 55.5% ± 12.1%<br>10-year survival: 17.3% ± 14.1%<br>20-year survival: 13.6% ± 11.3% | freedom from reoperation at 20 years:<br>AL: 83.0%<br>BL: 96.2%<br>MR recurrence: N/A | Reoperation or freedom from reoperation: N/A<br>MR recurrence: N/A |

Abbreviations: MR: mitral regurgitation, PL: posterior leaflet, AL: anterior leaflet, BL: bileaflet.

repair group was noted (0.74% vs. 0.48%). A variety of techniques were used for anterior leaflet repair in this study.[27] Similarly, in the study by Gillinov et al., early and late survival was similar in both groups after propensity score matching. Compared with patients with posterior repair, those with anterior repair had similar unadjusted and propensity-adjusted early risk of reoperation. Late risk of reoperation was higher; however, the anterior repair group had older patients with more comorbidities.[7] In a study that reviewed the outcomes of anterior, posterior, and bileaflet mitral valve repair in 760 consecutive patients, Eilon Ram et al. found no difference in in-hospital or 30-day mortality and similar rates of reoperation and late deaths. The strongest predictor for recurrent MR was post-operative residual mild MR. Also, the use of larger annuloplasty ring was associated with recurrent MR in patients with fibroelastic deficiency or significant leaflet resection.[42] Similarly, in the study by Spiegelstein et al., the rates of early and late mortality, complications, and freedom from reoperation were essentially the same for anterior and posterior repair. Anterior repair showed a higher rate of freedom from moderate or severe MR recurrence.[41] Finally, the study by Michele De Bonis et al. about edge-to-edge repair of anterior leaflet and quadrangular resection of the posterior leaflet, with or without sliding-plasty showed better 10-year survival, freedom from cardiac death, and freedom from reoperation, although there was a higher rate of in-hospital mortality in the posterior repair group.[43]

**5.2. COMPARISON OF ANTERIOR REPAIR VERSUS VALVE REPLACEMENT.** Only 1 retrospective study compared anterior mitral leaflet repair with valve replacement. A total number of 501 patients were included, 475 of which underwent anterior or bileaflet repair. Unadjusted 30-day mortality was higher in the replacement vs. repair group (1.8% vs. 1.2%). 1-year, 5-year, 10-year, and 20-year survival was 96.2% ± 1.3%, 86.5% ± 2.4%, 66.3% ± 4.1%, and 43.4% ± 5.5% for repair and 80% ± 8.9%, 55.5% ± 12.1%, 17.3% ± 14.1%, and 13.6% ± 11.3% for replacement, respectively. After multivariable analysis, replacement was a separate predictor of late mortality, along with left ventricular dysfunction, NYHA III-IV heart failure symptoms, and higher levels of pulmonary artery pressure.[25]

## 6. DISCUSSION

The salient findings of the current review are the following: i) a variety of surgical techniques and approaches are available for anterior mitral leaflet repair, and ii) there are no randomized-controlled trials comparing outcomes of anterior repair with isolated posterior repair or replacement. Based on available retrospective cohorts: iii) anterior leaflet repair is associated with similar outcomes compared to isolated posterior leaflet repair, even when the anterior leaflet is repaired as part of bileaflet repair, and iv) anterior leaflet repair is associated with improved outcomes when compared to valve replacement.

Posterior mitral leaflet repair is an established surgery for degenerative MR that is superior to valve replacement. Among 87,214 patients who underwent mitral valve surgery between 2011 and 2016, unadjusted operative mortality was 3.7% for replacement and 1.1% for repair. The most common underlying pathology was leaflet prolapse (60.7%), and the overall mitral valve repair rate was 65.6%. Surgical repair techniques included prosthetic annuloplasty (94.3%), leaflet resection (46.5%), and artificial cord implantation (22.7%).[44]

Therefore, surgical repair is the recommended surgery for degenerative MR of the posterior leaflet, when feasible,[3] as stated in the 2021 ESC/EACTS and 2020 ACC/AHA Guidelines for the management of valvular heart disease.[3, 45]

The anterior leaflet is involved in almost half of the patients with degenerative MR. Due to the technical complexity of anterior repair, replacement has been traditionally preferred over repair in these cases[46] and, isolated anterior repair is performed less frequently than posterior repair.[38] However, there has been substantial improvement in anterior leaflet repair techniques over the recent years. Older techniques such as resection, chordal shortening, and transfer carry a higher risk of early failure due to remaining pathologic chordae compared to more novel techniques such as artificial chordae replacement.[13] It has been recently suggested that the majority of patients with degenerative MR from anterior leaflet pathology can now be repaired with contemporary surgical methods.[7]

As in the case of isolated posterior leaflet repair, preservation of the native valve reduces many of the risks typically related to prosthetic valve replacement, such as thromboembolism, endocarditis, anticoagulant-related hemorrhage, and need for reoperation.[32, 47] In addition, repair preserves the sub-valvular apparatus and thus left ventricular geometry, which is very important for the left ventricular function. From that point of view, mitral valve repair should be preferred, even when anticoagulation is indicated.[48]

An important point to be mentioned is that outcomes of anterior repair depend heavily on surgical

skills, experience, and expertise.[25] Patients who undergo anterior leaflet repair in high-volume, experienced centers have similarly favorable outcomes to isolated posterior repair.[25, 41]

Lastly, transcatheter interventions such as edge-to-edge repair and transcatheter valve implantation can nowadays offer solutions to patients' anterior leaflet pathology and high or prohibitive surgical risk.[49] Given the complex decisions that are required for the treatment of degenerative MR and the number of available choices (anterior leaflet repair, replacement, and transcatheter repair), multidisciplinary teams are crucial for the best approach to its individual patient.

**LIMITATIONS.** The existing evidence on the outcomes of anterior mitral leaflet repair for degenerative MR and the comparison to posterior leaflet repair and valve replacement currently derives from retrospective studies with significant heterogeneity and relatively limited number of patients, increasing the risk for selection bias and other confounding factors. Despite the potential benefits of anterior repair with the utilization of contemporary surgical techniques, its widespread application is currently limited by operator experience and expertise. Randomized-controlled trials comparing directly anterior mitral leaflet repair techniques to posterior or bileaflet repair techniques and valve replacement are required to further define the optimal surgical strategy for patients with degenerative MR.

**CONCLUSION.** Surgical repair of the anterior mitral leaflet with the utilization of contemporary techniques is nowadays feasible in experienced tertiary centers, with outcomes that are comparable to posterior leaflet repair and possibly better than valve replacement. Randomized-controlled trials comparing modern repair techniques to replacement are required to validate these findings.

## DECLARATION OF INTERESTS

The authors report no relationships that could be construed as a conflict of interest.

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## REFERENCES

**1.** Roth GA, Mensah GA, Fuster V. The global burden of cardiovascular diseases and risks: a compass for global action. *J Am Coll Cardiol*. 2020;76(25):2980–2981.

**2.** Koell B, Kalbacher D, Lubos E. Current devices and interventions in mitral regurgitation. *Herz*. 2021;46(5):419–428.

**3.** Otto CM, Nishimura RA, Bonow RO, et al. 2020 ACC/AHA guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2021;77(4):450–500.

**4.** Gillinov AM, Cosgrove DM, Blackstone EH, et al. Durability of mitral valve repair for degenerative disease. *J Thorac Cardiovasc Surg*. 1998;116(5):734–743.

**5.** David TE, Ivanov J, Armstrong S, Christie D, Rakowski H. A comparison of outcomes of mitral valve repair for degenerative disease with posterior, anterior, and bileaflet prolapse. *J Thoracic Cardiovasc Surg*. 2005;130(5):1242–1249.

**6.** Schaff HV, Nguyen A. Contemporary techniques for mitral valve repair-the Mayo Clinic experience. *Indian J Thorac Cardiovasc Surg*. 2020;36(Suppl 1):18–26.

**7.** Gillinov AM, Alaulaqiet A, et al. Outcomes after repair of the anterior mitral leaflet for degenerative disease. *Annals Thoracic Surg*. 2008;86(3):708–717.

**8.** Karagodin I, Singh A, Lang RM. Pathoanatomy of mitral regurgitation. *Struct Heart*. 2020;4(4):254.

**9.** Topilsky Y. Mitral regurgitation: anatomy, physiology, and pathophysiology-lessons learned from surgery and cardiac imaging. *Front Cardiovasc Med*. 2020;7.

**10.** Chehab O, Roberts-Thomason R, Ng Yin Ling C, et al. Secondary mitral regurgitation: pathophysiology, proportionality and prognosis. *Heart*. 2020;106(10):716–723.

**11.** Aluru JS, Barsouk A, Saginala K, Rawla P, Barsouk A. Valvular heart disease epidemiology. *Med Sci (Basel)*. 2022;10(2).

**12.** Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(23):2440–2492.

**13.** Chemtob RA, Wierup P, Mick S, Gillinov M. Choosing the 'Best' surgical techniques for mitral valve repair: Lessons from the literature. *J Card Surg*. 2019;34(8):717–727.

**14.** Evans CF, DeFilippi CR, Shang E, Griffith BP, Gammie JS. Fresh autologous pericardium for leaflet perforation repair in mitral valve infective endocarditis. *J Heart Valve Dis*. 2013;22(4):560–566.

**15.** Perier P. Surgical repair of the prolapsing anterior leaflet with chordal shortening. *Semin Thorac Cardiovasc Surg*. 2004;16(2):174–181.

**16.** Gillinov AM, Cosgrove DM. Chordal transfer for repair of anterior leaflet prolapse. *Semin Thorac Cardiovasc Surg*. 2004;16(2):169–173.

**17.** Perier P, Hohenberger W, Batz G, Lakew F, Diegeler A. Mitral valve repair for degenerative mitral valve regurgitation. *Indian J Thoracic Cardiovasc Surg*. 2020;36(Suppl 1):12.

**18.** DAVID TE. Replacement of chordae tendineae with expanded polytetrafluoroethylene sutures. *J Card Surg*. 1989;4(4):286–290.

**19.** Calafiore AM, Contini M, Iacò AL, Di Mauro M, Bivona A, Weltert L. Mitral valve repair for degenerative mitral regurgitation. *J Cardiovasc Med (Hagerstown)*. 2007;8(2):114–118.

**20.** Montanhesi PK, Ghoneim A, Gelinas J, Chu MWA. Simplifying mitral valve repair: a guide

to neochordae reconstruction. *Innovations (Phila)*. 2022;17(4):343.

**21.** Ibrahim M, Rao C, Athanasiou T. Artificial chordae for degenerative mitral valve disease: critical analysis of current techniques. *Interact Cardiovasc Thorac Surg*. 2012;15(6):1019-1032.

**22.** Dreyfus GD, Bahrami T, Alayle N, Mihealainu S, Dubois C, De Lentdecker P. Repair of anterior leaflet prolapse by papillary muscle repositioning: a new surgical option. *Ann Thorac Surg*. 2001;71(5):1464-1470.

**23.** Pozzoli A, Vicentini L, De Bonis M, Di Giannuario G, La Canna G, Alfieri O. Contemporary application of the edge-to-edge repair. *Ann Cardiothorac Surg*. 2015;4(4):376.

**24.** Nisivaco S, McCarthy PM, Kruse J, Andre A-C, Zhao M, Thomas JD. Late results of chord transfer and other techniques for anterior leaflet repair without neochords. *J Thorac Cardiovasc Surg*. 2023. https://doi.org/10.1016/J.JTCVS.2023.05.047

**25.** Coutinho GF, Correia PM, Branco C, Antunes MJ. Long-term results of mitral valve surgery for degenerative anterior leaflet or bileaflet prolapse: analysis of negative factors for repair, early and late failures, and survival. *Eur J Cardiothorac Surg*. 2016;50(1):66-74.

**26.** Seeburger J, Borger MA, Doll N, et al. Comparison of outcomes of minimally invasive mitral valve surgery for posterior, anterior and bileaflet prolapse. *European J Cardio-thoracic Surg*. 2009;36(3):532-538.

**27.** Brescia AA, Watt TMF, Rosenbloom LM, et al. Anterior versus posterior leaflet mitral valve repair: A propensity-matched analysis. *J Thoracic Cardiovascular Surg*. 2021;162(4):1087-1096.e3.

**28.** Mohr FW, Falk V, Diegeler A, et al. Minimally invasive port-access mitral valve surgery. *J Thoracic Cardiovasc Surg*. 1998;115(3):567-576.

**29.** Suri RM, Schaff HV, Meyer SR, Hargrove WC. Thoracoscopic versus open mitral valve repair: a propensity score analysis of early outcomes. *Annals Thoracic Surg*. 2009;88(4):1185-1190.

**30.** Yokoyama Y, Kuno T, Takagi H, Briasoulis A, Ota T. Conventional sternotomy versus right minithoracotomy versus robotic approach for mitral valve replacement/repair: insights from a network meta-analysis. *J Cardiovasc Surg (Torino)*. 2022;vol. 63(4):492-497.

**31.** Castillo JG, Anyanwu AC, El-Eshmawi A, Adams DH. All anterior and bileaflet mitral valve prolapses are repairable in the modern era of reconstructive surgery. *Eur J Cardiothorac Surg*. 2014;vol. 45(1):139-145.

**32.** Brescia AA, Watt TMF, Murray SL, et al. Rheumatic mitral valve repair or replacement in the valve-in-valve era. *J Thoracic Cardiovasc Surg*. 2022;163(2):591-602.e1.

**33.** Morimoto H, Tsuchiya K, Nakajima M, Akashi O. Mitral valve repair for anterior leaflet prolapse: surgical techniques review and 16-year follow-up results. *J Card Surg*. 2008;23(5):426-430.

**34.** De Bonis M, Lapenna E, Taramasso M, et al. Very long-term durability of the edge-to-edge repair for isolated anterior mitral leaflet prolapse: up to 21 years of clinical and echocardiographic results. *J Thorac Cardiovasc Surg*. 2014;148(5):2027-2032.

**35.** Kadiroğulları E, Çiçek ÖF, Mola S, et al. Comparison of anterior mitral leaflet repair techniques with and without the use of chordal replacement in patients with degenerative mitral valve insufficiency. *Heart Surg Forum*. 2019;22(3):E234-E240.

**36.** Maeda S, Funatsu T, Kondoh H, et al. Intermediate-term outcomes of our original multiple-knot technique using ePTFE sutures for anterior mitral leaflet prolapse. *Surg Today*. 2019;49(4):350-356.

**37.** Pfannmüller B, Seeburger J, Misfeld M, Borger MA, Garbade J, Mohr FW. Minimally invasive mitral valve repair for anterior leaflet prolapse. *J Thorac Cardiovasc Surg*. 2013;vol. 146(1):109-113.

**38.** Edge-to-edge chordal transfer repair for anterior leaflet prolapse of mitral valve in 21 patients - PubMed [Online]. Accessed April 3, 2023. https://pubmed.ncbi.nlm.nih.gov/21034542/

**39.** Fucci C, De Cicco G, Chiari E, et al. Edge-to-edge mitral valve repair for isolated prolapse of the anterior leaflet caused by degenerative disease. *J Cardiovasc Med (Hagerstown)*. 2007;8(5):354-358.

**40.** Kasegawa H, Shimokawa T, Shibazaki I, Hayashi H, Koyanagi T, Ida T. Mitral valve repair for anterior leaflet prolapse with expanded polytetrafluoroethylene sutures. *Ann Thorac Surg*. 2006;81(5):1625-1631.

**41.** Spiegelstein D, Sternik L, Orlov B, et al. Mitral valve repair: isolated posterior compared to anterior or bileaflet pathology. *J Card Surg*. 2013;28(2):89-96.

**42.** Ram E, Schwammenthal E, Cohen H, et al. Outcomes of degenerative mitral valve repair surgery for anterior, posterior, and bileaflet pathology. *Annals Thoracic Surg*. 2020;110(3):934-942.

**43.** De Bonis M, Lorusso R, Lapenna E, et al. Similar long-term results of mitral valve repair for anterior compared with posterior leaflet prolapse. *Journal of Thoracic and Cardiovascular Surgery*. Feb. 2006;131(2):364-370. https://doi.org/10.1016/j.jtcvs.2005.09.040

**44.** Gammie JS, Chikwe J, Badhwar V, et al. Isolated mitral valve surgery: the society of thoracic surgeons adult cardiac surgery database analysis. *Annals Thoracic Surg*. 2018;106(3):716-727.

**45.** Vahanian A, Beyersdorf F, Praz F, et al. 2021 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J*. 2022;43(7):561-632.

**46.** Mick SL, Keshavamurthy S, Gillinov AM. Mitral valve repair versus replacement. *Ann Cardiothorac Surg*. 2015;vol. 4(3):230.

**47.** Raman J, Shah P, Seevanayagam S, Cheung J, Buxton B. Mitral regurgitation: comparison between edge-to-edge repair and valve replacement. *Asian Cardiovasc Thorac Ann*. 2003;11(2):131-134.

**48.** Romano MA, Patel HJ, Pagani FD, Prager RL, Deeb GM, Bolling SF. Anterior leaflet repair with patch augmentation for mitral regurgitation. *Ann Thorac Surg*. 2005;79(5):1500-1504.

**49.** Saito T, Kuno T, Ueyama HA, et al. Transcatheter edge-to-edge mitral valve repair for mitral regurgitation in patients with cardiogenic shock: A systematic review and meta-analysis. *Catheter Cardiovasc Interv*. 2023. https://doi.org/10.1002/CCD.30944

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