

Alfieri versus conventional repair for bileaflet mitral valve prolapse



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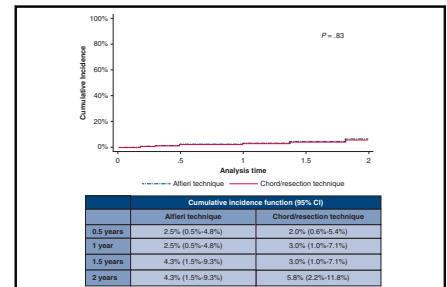
ABSTRACT

Objective: Mitral valve repair for bileaflet prolapse can be complex, involving multiple chords or resection. The Alfieri technique for bileaflet disease is simple but may be associated with mitral stenosis or recurrent mitral regurgitation. Outcomes of patients with bileaflet prolapse undergoing mitral valve repair using the Alfieri versus conventional chord/resection techniques were compared.

Methods: Adults undergoing mitral valve repair for bileaflet prolapse for degenerative disease from 2017 to 2023 were stratified by repair technique. Outcomes including operative mortality and echocardiogram data were compared. Time to event analysis was used to characterize freedom from recurrent mitral regurgitation (moderate or greater mitral regurgitation).

Results: Among 188 patients with bileaflet prolapse, 37% (70) were repaired with the Alfieri and the remaining patients were repaired with chords/resection. Compared with chords/resection, patients undergoing the Alfieri had shorter cardiopulmonary bypass and crossclamp times. Operative mortality (0% [0/70] vs 2% [2/118], $P = .27$) was similar between both techniques. The mean mitral gradient was low and similar for the Alfieri versus chords/resection (3 vs 3, $P = .34$). Development of recurrent mitral regurgitation at 2 years, incorporating the competing risk of death and mitral reintervention, was 4.3% (95% CI, 1.5%-9.3%) for the Alfieri technique and 5.8% (95% CI, 2.2%-11.8%) for chord/resection ($P = .83$).

Conclusions: Both the Alfieri and chord/resection techniques had low rates of recurrent mitral regurgitation at 2 years. The mitral valve gradient was low and similar regardless of technique; thus, those who received the Alfieri technique did not have an increased rate of mitral stenosis. The Alfieri may be an underused technique for bileaflet prolapse. (JTCVS Open 2023;16:242-9)



Development of recurrent MR was rare with the Alfieri technique.

CENTRAL MESSAGE

Bileaflet prolapse can be effectively repaired with the Alfieri technique, with excellent freedom from recurrent MR and mitral reintervention, and no development of mitral stenosis.

PERSPECTIVE

The Alfieri technique can be used as a simple primary repair technique for bileaflet prolapse. An annuloplasty ring can decrease recurrent MR, and use of a larger ring size can mitigate the risk of iatrogenic mitral stenosis. If surgeons achieve an excellent intraoperative repair with trivial or less MR, the repair approach does not matter.

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Funding: C.M.W. receives salary support through the Institute for Healthcare Policy and Innovation as a part of the National Clinician Scholars Program. W.F. is funded by the National Institutes of Health T32 Multidisciplinary Training Program in Lung Disease (T32HL007749).

Read at the 2023 AATS Mitral Conclave Workshop, New York, NY, May 4-5, 2023.

Received for publication June 1, 2023; revisions received Sept 12, 2023; accepted for publication Oct 3, 2023; available ahead of print Nov 22, 2023.

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<https://doi.org/10.1016/j.xjon.2023.10.005>

Bileaflet prolapse due to degenerative mitral valve disease is challenging to successfully repair.¹⁻⁶ In most cases, bileaflet prolapse is repaired with a combination of chord or resection techniques.⁶⁻⁸ However, these techniques are complex, and many patients with bileaflet prolapse treated in the community receive a mitral valve replacement.^{1,5,6}

Abbreviations and Acronyms

MR = mitral regurgitation
MVR = mitral valve repair

A simpler alternative to chord/resection techniques for bileaflet prolapse when feasible is the Alfieri technique (edge-to-edge repair).⁹⁻¹³ However, in the United States, there is concern that the Alfieri technique may be associated with iatrogenic mitral stenosis due to narrowing of the mitral orifice and higher rates of recurrent mitral regurgitation (MR).¹⁴⁻¹⁸ As such, the Alfieri has been commonly reserved as a “bailout method” after failed attempt at mitral valve repair (MVR) or systolic anterior motion of the mitral valve.^{14,17} However, internationally, select groups report excellent freedom from recurrent MR and low rates of mitral valve reintervention when using the Alfieri technique as the primary repair technique for bileaflet prolapse.^{5,9-12} It may be that the Alfieri technique, when used as a primary repair technique for bileaflet prolapse, can offer a simple, durable MVR for these complicated lesions.

In this study, we sought to describe the outcomes of patients with degenerative mitral valve disease with bileaflet prolapse who were repaired with the Alfieri technique versus chord/resection technique at an American Heart Association Mitral Valve Reference Center. Specifically, we sought to compare the durability of MVR and development of mitral stenosis between the Alfieri and chord/resection techniques to identify if the Alfieri is an appropriate primary repair technique for bileaflet prolapse.

PATIENTS AND METHODS

Data Source

This study was deemed exempt from review and individual consent by the University of Michigan Institutional Review Board (HUM00148119, August 2018). Patient demographics, operative characteristics, and outcomes data were collected through the University of Michigan institutional component of the Society of Thoracic Surgeons Adult Cardiac Surgery Database. Follow-up echocardiogram and mitral valve reintervention data were assessed through chart review.

Patient Population

All adult patients with degenerative mitral valve disease with bileaflet prolapse who underwent MVR from 2017 to 2023 at our institution were included (n = 188). Operative notes were reviewed to identify MVR techniques. Patients were stratified by repair technique (Alfieri 37%, n = 70; chord/resection 63%, n = 118).

Description of the Alfieri Technique

Surgical approach included sternotomy, thoracotomy, and minithoracotomy, and varied depending on surgeon preference and patient factors (eg, prior cardiac surgery). Patients underwent bicaval cannulation for optimal visualization, and the mitral valve was typically approached through the interatrial groove. The Alfieri technique was typically selected for patients with symmetric bileaflet prolapse with prolapse located centrally at A2/

P2. The free edges of the leaflets at A2/P2 were sewn together with a horizontal mattress stitch and imbricated, displacing the zone of coaptation into the ventricle (the “double orifice” technique) (Video 1). As others have described, deep bites are taken on the leaflet to (1) reduce redundant tissue, (2) reduce the leaflet height, and (3) reduce tension on the stitch to prevent tearing.^{9,11} In conjunction with the Alfieri stitch, a partial annuloplasty ring was always placed to reinforce the repair and prevent annular dilation and development of recurrent MR.^{15,19}

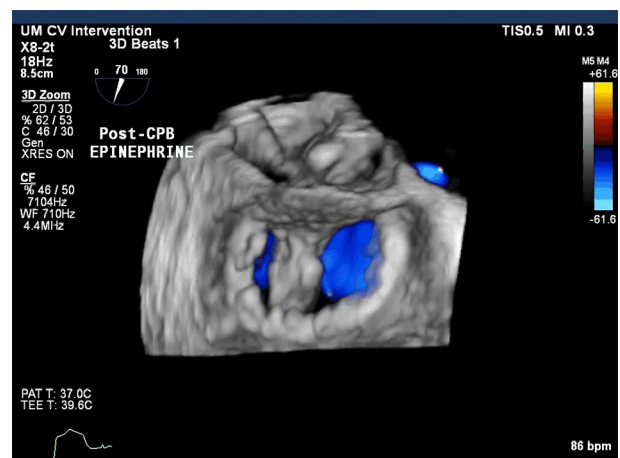
Outcomes

Primary outcomes examined postoperative echocardiogram outcomes and need for mitral valve reintervention. Data were collected using the most recent echocardiogram available. Atrioventricular valve regurgitation grade was coded 0 for trivial/none, 1 for mild, 2 for moderate, 3 for moderate-severe, and 4 for severe. Recurrent MR was defined as grade 2 or greater MR. Mean mitral gradient at follow-up echocardiogram was recorded. Need for mitral valve reintervention was assessed with chart review.

Secondary outcomes were major morbidity and short- and long-term mortality. Major morbidity was defined in accordance with the Society of Thoracic Surgeons Performance Measures and includes having any of the following postoperative complications: (1) reoperations for any cardiac reason, including valvular dysfunction or postoperative bleeding; (2) renal failure; (3) deep sternal wound infection; (4) prolonged ventilation/intubation; and (5) cerebrovascular accident/permanent stroke. The 30-day mortality was defined as in-hospital or within 30 days of the index operation. Date of follow-up was defined as the most recent clinic or chart encounter in the electronic medical record. Date of death was assessed through retrospective chart review.

Statistical Analysis

Descriptive data were collected and analyzed using frequencies and proportions. Categorical variables are presented as percentages of the total number of patients. Continuous variables were tested for normality using the Shapiro–Wilk test. All continuous variables were not normally distributed and are presented as median with interquartile range. Comparisons between groups were performed using the Wilcoxon rank sum for continuous variables and chi-square for categorical variables. Overall follow-up was



VIDEO 1. Postrepair intraoperative transesophageal echocardiogram using the Alfieri technique. The bileaflet prolapse was repaired using the Alfieri technique, placing a stitch at A2/P2. There was an excellent intraoperative MVR with no MR. Video available at: [https://www.jtcvs.org/article/S2666-2736\(23\)00317-0/fulltext](https://www.jtcvs.org/article/S2666-2736(23)00317-0/fulltext).

100% complete. There were missing data for long-term echocardiographic follow-up, and the follow-up data presented outcomes of patients with long-term follow-up data available. Kaplan–Meier analysis was performed to characterize survival. A Fine-Gray model was performed to compare freedom from recurrent MR with the competing risks of mitral reintervention and death. The cumulative incidence function with 95% CI is provided. Analyses were performed using Stata 17.0 (StataCorp LLC).

RESULTS

Patient Characteristics

A total of 188 patients were included, of whom 37% (70) underwent repair with the Alfieri technique, and the remaining patients underwent repair with the chord/resection technique. For the entire cohort, the median age was 65 (54-72) years, 39% (73) were female, and 31% (58) had preoperative atrial fibrillation, which did not differ based on repair technique (Table 1). The median patient-reported outcome measure score was 0.67% for those who underwent the Alfieri technique and 0.59% for those who underwent the chord/resection technique.

Operative Characteristics

The median cardiopulmonary bypass time was 78 (64-98) minutes for the Alfieri technique versus 122 (77-169) minutes for the chord/resection technique ($P < .001$) (Table 2). Crossclamp time was shorter in the Alfieri group (61 [48-76] minutes vs 95 [58-123] minutes, $P < .001$). Both the Alfieri technique group and the chord/resection group received a large ring size (38 vs 36, $P = .009$). Intraoperatively, more than 90% of patients for both the Alfieri and chord/resection groups had trivial or less MR postrepair. No patients were left with moderate or greater MR.

Outcomes: Major Morbidity and Mortality

Rate of major morbidity was 7% for the Alfieri technique and 17% for the chord/resection technique ($P = .056$) (Table 3). For the Alfieri technique, wound infection and stroke were the most common complications, followed by prolonged ventilation. For the chord/resection technique, prolonged ventilation was the most common complication, followed by stroke, reoperation, and new renal failure. Operative mortality was 0% (0) for the Alfieri technique and 2% (2/118) for the chord/resection technique ($P = .271$). Long-term survival was also similar among both groups. On Kaplan–Meier analysis, 2-year survival was 92% (95% CI, 74%-97%) for the Alfieri group and 97% (95% CI, 90%-98%) for the chord/resection group ($P = .194$) (Figure 1).

Outcomes: Postoperative Echocardiogram and Need for Mitral Reintervention

Of the 188 patients, 75% (140) had a postoperative echocardiogram at a median of 3 (1-19) months after surgery. At follow-up, the median mean mitral valve gradient for the Alfieri technique was 3 (3-5) mm Hg and was not different from the chord/resection technique (3 [3-4] mm Hg, $P = .341$) (Figure 2). Incorporating the competing risks of death and mitral reintervention, freedom from recurrent MR at 2 years was 96% (95% CI, 91%-99%) for the Alfieri technique and 94% (95% CI, 88%-98%) for the chord/resection technique ($P = .83$) (Figure 3).

Four patients required mitral reintervention, 2 patients who were repaired with the Alfieri technique and 2 patients who were repaired with chord/resection. The first Alfieri patient who required reintervention developed endocarditis of

TABLE 1. Preoperative characteristics

Characteristic	Alfieri (n = 70)	Chords/resection (n = 118)	P value
Age, y	65 (59-72)	63 (50-72)	.196
Female	27 (39%)	46 (39%)	.955
Diabetes	6 (8%)	5 (4%)	.221
Hypertension	46 (66%)	60 (51%)	.047
Preoperative atrial fibrillation	22 (31%)	36 (31%)	.896
Preoperative ejection fraction	60 (58-63)	60 (55-65)	.990
PROM score	0.67% (0.43%-1.37%)	0.59% (0.29%-1.20%)	.057
Redo surgery	3 (4%)	8 (7%)	.481
Urgent/emergency	2 (3%)	6 (5%)	.464
Class NYHA (n = 135)			.289
Class 1	12 (19%)	8 (12%)	
Class 2	39 (62%)	47 (65%)	
Class 3	8 (13%)	15 (21%)	
Class 4	4 (6%)	2 (3%)	

PROM, Patient-reported outcome measure; NYHA, New York Heart Association.

TABLE 2. Operative characteristics

Characteristic	Alfieri (n = 70)	Chords/resection (n = 118)	P value
Cardiopulmonary bypass time, min	78 (64-98)	121 (77-168)	<.001
Crossclamp time, min	61 (48-77)	94 (58-127)	<.001
Ring size	38 (36-38)	36 (30-38)	.009
Intraoperative MR postrepair			.213
Trivial or none	65 (93%)	105/114 (91%)	
Mild	5 (7%)	9 (9%)	
Moderate or greater	0 (0%)	0 (0%)	
Concomitant procedures			
Tricuspid valve	16 (23%)	35 (30%)	.270
Aortic valve replacement	1 (1%)	4 (3%)	.406
Atrial fibrillation procedure	23 (33%)	38 (32%)	.990
CABG	7 (10%)	8 (7%)	.459
No. of crossclamps			.47
0	4 (6%)	3 (2%)	
1	62 (90%)	107 (92%)	
2	3 (4%)	7 (6%)	
3	0 (0%)	1 (<1%)	
4	1 (<1%)	0 (0%)	

MR, Mitral regurgitation; CABG, coronary artery bypass grafting.

their mitral annuloplasty ring after a Mohs procedure and underwent mitral valve replacement 4 years after the index operation. The second Alfieri patient who required reintervention developed thickening of the anterior leaflet with recurrent MR and underwent mitral valve replacement 2 years after their index operation. The first chord/resection patient who required reintervention had dehiscence of the annuloplasty ring and a large tear in the anterior leaflet from cord dehiscence and underwent mitral valve replacement 3 weeks after their index operation. The second chord/resection patient who required reintervention developed A3 prolapse 3 years after the index operation and underwent MVr with commissural advancement.

DISCUSSION

This study comparing outcomes for patients with bileaflet prolapse who underwent MVr with the Alfieri or chord/

resection technique had 2 primary findings. First, those who received the Alfieri technique had similar mitral gradients as those with conventional chord/resection techniques, suggesting that at least for this midterm analysis, the Alfieri technique does not increase risk of mitral stenosis. Second, the Alfieri technique had excellent freedom from recurrent MR and reintervention, which was comparable to the chord/resection technique. Taken together, at 2 years, the Alfieri technique is a durable valve repair technique for symmetric, bileaflet prolapse involving A2/P2.

Although both transcatheter edge-to-edge repair and the Alfieri technique are edge-to-edge repairs, there are 3 key differences. First, transcatheter edge-to-edge repairs are primarily used for functional MR and include a different patient population than patients with degenerative MR, where surgical MVr is the gold standard. Second, the Alfieri technique imbricates the leaflets, creating a longer zone of

TABLE 3. Outcomes

Characteristic	Alfieri (n = 70)	Chords/resection (n = 118)	P value
ICU readmission	1 (1%)	4 (3%)	.426
Major morbidity	5 (7%)	20 (17%)	.056
Wound infection	2 (3%)	0 (0%)	.065
Stroke	2 (3%)	7 (6%)	.348
Prolonged ventilation	1 (1%)	12 (10%)	.023
Renal failure	0 (0%)	3 (3%)	.200
Reoperation	0 (0%)	6 (5%)	.055
Operative mortality	0 (0%)	2 (2%)	.271
30-d readmission	13 (19%)	13 (11%)	.147

ICU, Intensive care unit.



FIGURE 1. Comparison of long-term survival for patients with bileaflet prolapse repaired with the Alfieri technique (black dashed) and chord/resection technique (grey). Two-year survival was 92% (95% CI, 74%-97%) for patients repaired with the Alfieri technique and 97% (95% CI, 90%-98%) for the chord/resection technique, a difference that was not significant ($P = .194$).

coaptation that has been shown to improve long-term durability of repairs with lower incidence of recurrent MR. Finally, during the Alfieri technique, an annuloplasty ring is placed to stabilize the repair and prevent annular dilation.^{2,20} Currently, there are no transcatheter mitral annuloplasty rings that have been successful. Because of these 3 key differences, our findings should not be interpreted to mean that transcatheter edge-to-edge repair is an effective technique for patients with bileaflet prolapse. The Alfieri technique and the transcatheter edge-to-edge repair technique have important differences, and surgery is still the gold standard for most patients with bileaflet prolapse.

The Alfieri technique may narrow the effective orifice area of the mitral valve, and some studies have raised concern that it causes iatrogenic mitral stenosis.^{12,17} One case series of 26 patients found that approximately one-quarter of patients with degenerative disease repaired with the Alfieri technique developed mitral stenosis over a 10-

year period.¹⁷ However, although there may be slightly elevated transmitral pressure gradients with the Alfieri,²¹ many larger studies from centers experienced with the Alfieri technique have found that these slightly elevated gradients do not lead to clinically significant mitral stenosis. One series with 121 patients repaired with the Alfieri technique reported no development of mitral stenosis over the 5-year follow-up.²² Others performed stress echocardiography to examine valve function and hemodynamics in patients repaired with the Alfieri technique and found that there was no mitral valve obstruction even in a high cardiac output physiologic state.^{10,20,23,24} Despite a narrowing of the orifice of the valve, it appears that actual development of mitral stenosis is rare. One factor that may be protective against development of mitral stenosis is use of a larger annuloplasty ring. In our series and several others that had low occurrence of mitral stenosis at late follow-up, patients repaired with the Alfieri technique had a larger ring size compared with patients repaired with other techniques.⁵ This suggests that risk of mitral stenosis with the Alfieri technique can be mitigated by using a larger annuloplasty ring.

Another possible concern with the Alfieri technique is development of recurrent MR.^{17,18} We had more than 95% freedom from recurrent MR at 2 years for patients repaired with the Alfieri technique. We suspect 2 factors may be contributing to these excellent outcomes. First, an annuloplasty ring was implanted in every patient. Lack of an annuloplasty ring at the time of repair using the Alfieri technique predicts recurrent MR.^{11,15,19} Some groups cite not placing an annuloplasty ring due to concerns of iatrogenic mitral stenosis,¹⁵ but our data suggest that placement of a larger annuloplasty ring mitigates this risk of mitral stenosis while reducing the risk of recurrent

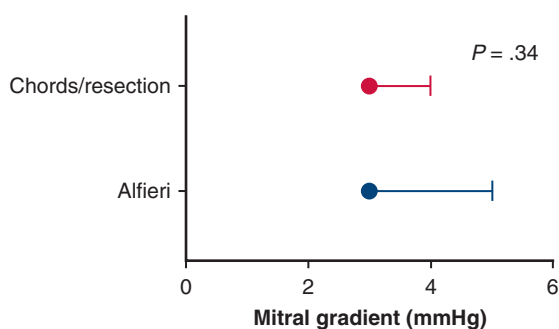
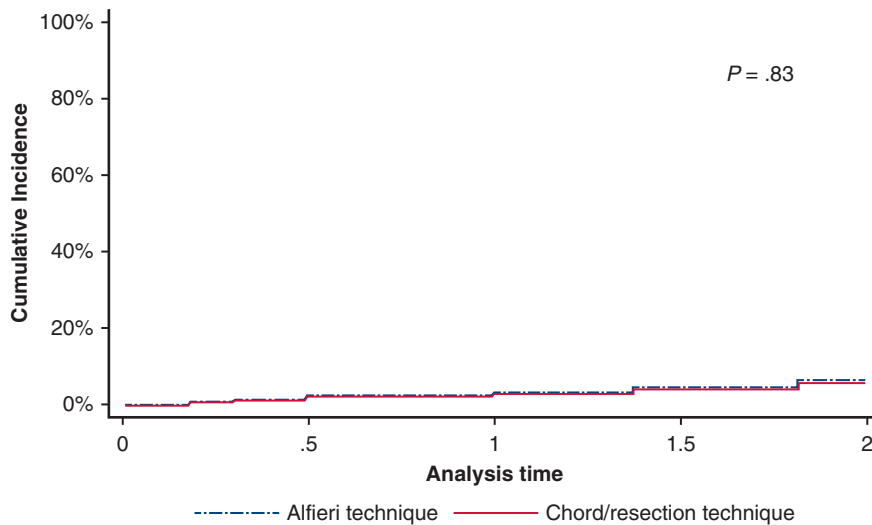


FIGURE 2. Comparison of mean mitral gradient at late echocardiographic follow-up for patients ($n = 140$) with bileaflet prolapse repaired with the Alfieri technique (black) and conventional chord/resection technique (grey). Median mitral valve gradient was 3 (3-5) for the Alfieri and 3 (3-4) for chord/resection, a difference that was not significant ($P = .34$).



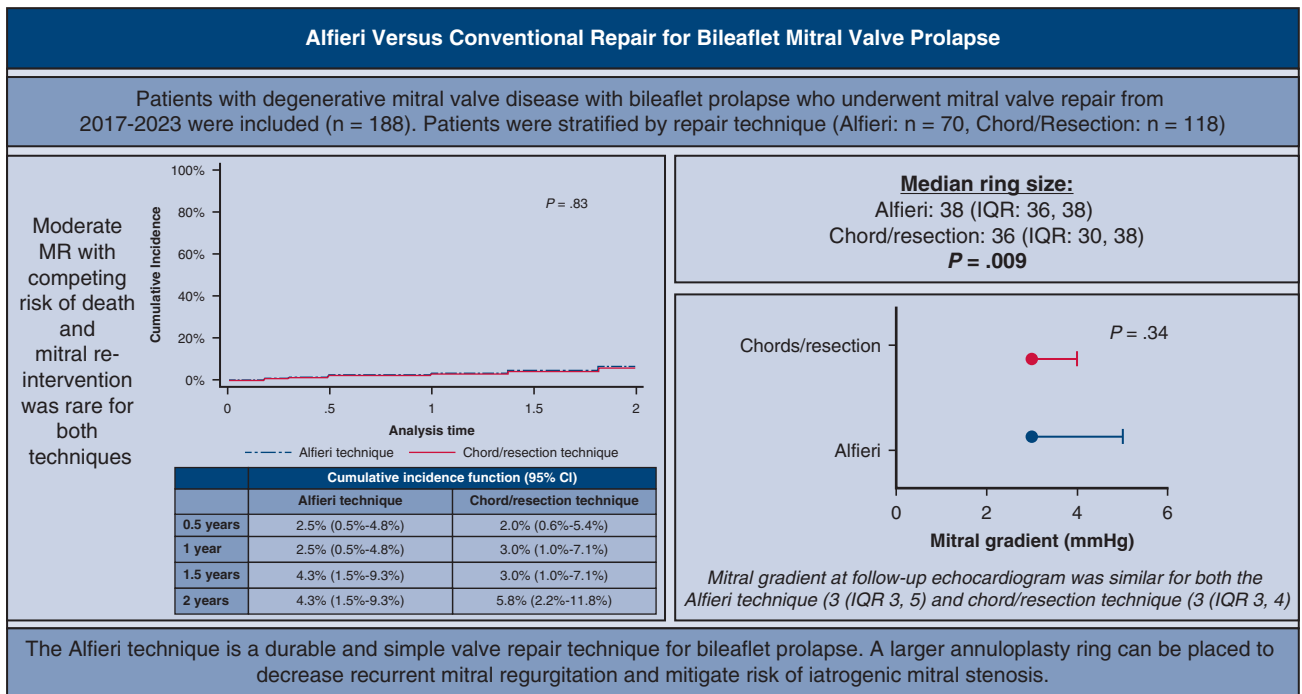
	Cumulative incidence function (95% CI)	
	Alfieri technique	Chord/resection technique
0.5 years	2.5% (0.5%-4.8%)	2.0% (0.6%-5.4%)
1 year	2.5% (0.5%-4.8%)	3.0% (1.0%-7.1%)
1.5 years	4.3% (1.5%-9.3%)	3.0% (1.0%-7.1%)
2 years	4.3% (1.5%-9.3%)	5.8% (2.2%-11.8%)

FIGURE 3. Comparison of freedom from recurrent MR (greater than mild) for patients with bileaflet prolapse repaired with the Alfieri technique (black dashed) and conventional chord/resection technique (grey). At 2 years, the cumulative incidence was 4.3% (95% CI, 1.5%-9.3%) for the Alfieri technique and 5.8% (95% CI, 2.2%-11.8%) for the chord/resection technique, a difference that was not significant ($P = .83$).

MR. Second, we used the Alfieri technique as a primary repair technique, and not as a “bailout method” after failure of other conventional valve repair techniques. Prior work has shown higher rate of reintervention and recurrence of MR when the Alfieri was used as a “bailout method” versus as a primary repair technique.¹⁹ This phenomenon may not be related to the technique itself, but rather that when surgeons use a “bailout method” they may be more willing to accept a less than perfect result for mitral repair. Maisano and colleagues¹⁹ found that patients repaired with the Alfieri technique who had trivial or less MR on intraoperative echocardiography had 94% freedom from recurrent MR at 4 years. Among patients who had mild or greater residual MR on intraoperative echocardiography, there was only 67% freedom from recurrent MR at 4 years.¹⁹ In our series, 92% of patients repaired with the Alfieri technique had trivial or less MR on intraoperative echocardiogram and no patients had moderate MR. These results suggest that regardless of repair technique used (Alfieri vs chord/resection), if an excellent MVr is achieved intraoperatively, patients can go on to have excellent freedom from recurrent MR and reintervention.

Study Limitations

Our study has several limitations. First, there was missingness in our follow-up echocardiograms, which may introduce bias. However, most patients had follow-up echocardiography. Although the median time to echocardiography was only 3 months, we historically have excellent capture of patients who develop recurrent MR or recurrent valvular disease. It is possible that patients are referred for recurrent MR at a different center and not captured here; however, we are one of the highest volume MVr centers nationally and are typically a center that receives referrals for failed repairs. In addition, our results echo other high-volume MVr centers that have used the Alfieri technique to repair bileaflet prolapse.^{5,9-12} Thus, we believe these results allow us to comment on the durability of the Alfieri technique, although the short follow-up time is a limitation and longer follow-up time would be ideal. Next, this was a highly selected group of patients with symmetric, central, bileaflet prolapse. Expert mitral surgeons know which patients can be successfully repaired with the Alfieri technique and which cannot. Our results may not be applicable to every patient with bileaflet prolapse. Additionally, these results are unadjusted, which may introduce bias due



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FIGURE 4. Graphical abstract. *IQR*, Interquartile range.

to confounding. However, the preoperative demographics were not statistically different, and all patients underwent surgery at a high-volume center, which should limit variation in the quality of operation received. Finally, this study occurred at a Mitral Foundation/American Heart Association Reference center, which may limit generalizability. However, the importance of experienced centers performing MVr has been increasingly recognized to optimize outcomes and increase the likelihood of successful MVr.

CONCLUSIONS

The Alfieri technique is a durable repair technique for select patients with bileaflet prolapse at 2 years (Figure 4). Iatrogenic mitral stenosis did not occur, which may be due to use of a larger annuloplasty ring. In this midterm analysis, the Alfieri technique led to excellent freedom from recurrent MR and low rate of reintervention. These results are likely due to use of an annuloplasty ring for every patient and excellent intraoperative repair result with more than 90% of patients having trivial or less MR on intraoperative echocardiogram. The Alfieri technique can be used as a primary repair technique for patients with bileaflet prolapse and not reserved only as a “bailout method.”

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: <https://www.aats.org/resources/alfieri-vs-conventional-chordal-repair-for-bileaflet-mitral-valve-prolapse>.



Conflict of Interest Statement

G.A. is a consultant for Abbott, Edwards, Medtronic, AtriCure, Arthrex, Jena, Ethicon, and Gore. S.F.B. is a consultant for Abbott, Edwards, Medtronic, AtriCure, and Gore. M.A.R. is a consultant for Edwards, Medtronic, and AtriCure. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: Alfieri, bileaflet prolapse, edge to edge, mitral valve repair