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ARTICLE

Ten-year survival after indirect mitral annuloplasty with the Carillon Mitral Contour System in functional mitral regurgitation. A single-center follow-up from the REDUCE FMR trial

Janusz Lipiecki,[1] Piotr Kalmucki,[2] Larry E. Miller,[3] Nicolas Durel[1]

[1]Department of Interventional Cardiology, Clinique Pole Sante Republique, Clermont-Ferrand, France; [2]Poznan University of Medical Sciences, HCP Medical Center, Poznań, Poland; [3]Department of Biostatistics, Miller Scientific, Johnson City, TN, United States

Abstract

Indirect mitral annuloplasty with the Carillon Mitral Contour System reduces regurgitant volume, induces favorable left ventricular remodeling, and is associated with favorable survival rates through 6 years; however, longer term data are limited.
This observational study included all 17 patients from a single center implanted with the Carillon device in the REDUCE-FMR trial. Patients had New York Heart Association class II-IV symp-toms, left ventricular ejection fraction <50%, and mitral regurgitation grade ≥2+ despite stable guideline-directed medical therapy. Patients underwent clinical and echocardiographic follow-up in the REDUCE-FMR trial for 1 year. Thereafter, vital status was ascertained after a median of 9.2 years (range: 8.0-10.3 years). Kaplan-Meier methods were used to estimate overall and cardiovascular survival. Univariable Cox regression was used to identify predictors of long-term mortality, with results reported as hazard ratios (HR) and 95% confidence intervals (95% CI).
The 10-year survival rate was 35% (median survival 5.6 years), and the corresponding cardiovascular survival rate was 66%. Baseline left ventricular ejection fraction <35% (HR=7.1; 95% CI: 1.4, 36.5; p=0.02), first-year heart failure hospitalization (HR=8.0; 95% CI: 2.0, 32.1; p=0.004), and tent height decrease during the first year (HR=5.1; 95% CI: 1.3, 20.8; p=0.02) were associated with increased all-cause mortality. First-year heart failure hospitalization (HR=9.6; 95% CI: 1.1, 88.8; p=0.046) was the only variable associated with higher cardiovascular mortality.
This study provides the first evidence of survival beyond 6 years after indirect mitral annuloplasty with the Carillon device, with 10-year outcomes suggesting durability of this treatment.

Key words: carillon, indirect mitral annuloplasty, mitral valve, REDUCE-FMR, survival.

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**Correspondence to: Larry E. Miller, Department of Biostatistics, Miller Scientific, 3101 Browns Mill Rd, Ste 6, Johnson City, TN, United States. E-mail: larry@millerscientific.com*

Introduction

Functional mitral regurgitation (FMR) affects approximately 50% of paients with heart failure (HF),[1] and the mortality risk increases with MR severity.[2] Guideline-directed medical therapy (GDMT) remains the cornerstone of FMR management,[3,4] but focused management of the FMR may provide additional benefit. Surgical mitral valve repair offers an alternative, but has limited utility in elderly, high-risk patients with significant comorbidities.[5,6] Transcatheter mitral valve repair approaches have been developed to bridge this treatment gap by reducing HF symptoms and improving quality of life through minimally invasive techniques.[7,8]
The Carillon Mitral Contour System (Cardiac Dimensions, Kirkland, WA, USA) performs indirect mitral annuloplasty by applying tension to the coronary sinus, which cinches the mitral annulus and reduces the regurgitant orifice area. Multiple studies have demonstrated that Carillon implantation induces favorable LV remodeling, reduces MR grade, and improves functional status and quality of life.[9-13] A pooled analysis of

three Carillon studies (TITAN, TITAN II, and REDUCE-FMR)[11-13] reported a 56% survival rate at 5 years.[14] Single-center data from REDUCE-FMR participants showed a 60% survival rate at 6 years.[15] These outcomes compare favorably to the reported 5-7 year survival rates of 22-43% with MitraClip and 33-40% with GDMT alone.[16-20] To the best of our knowledge, no transcatheter mitral valve repair study has examined survival beyond 7 years.[20] This single-center study addresses this knowledge gap by following REDUCE-FMR patients treated with the Carillon device for 10 years post-implantation. The primary objectives of this study were to determine the 10-year survival rate after Carillon implantation and identify patient characteristics associated with long-term mortality.

Materials and Methods

Study design

This observational single-center extension of the REDUCE-FMR trial followed patients for up to 10 years after treatment. REDUCE-FMR was a multicenter, randomized, double-blind, sham-controlled trial that evaluated the safety and efficacy of indirect mitral annuloplasty with the Carillon device compared to GDMT.[13] Our site treated 17 patients with the Carillon device and 8 with GDMT. Due to insufficient sample size for statistical analysis of mortality determinants in the GDMT group, we report outcomes for patients receiving Carillon device implantation.

Patients

Key eligibility criteria in REDUCE-FMR included New York Heart Association (NYHA) class II-IV symptoms, left ventricular (LV) ejection fraction <50%, LV end-diastolic diameter >55 mm, FMR grade 2+ to 4+ despite stable GDMT for ≥3 months, and a 6-minute walk distance of 150-450 meters. Key exclusion criteria included recent percutaneous coronary intervention, prior mitral surgery, organic mitral valve pathology, severe mitral annular calcification, and indications for cardiac resynchronization therapy. Quantitative transthoracic echocardiography was performed to assess anatomic suitability with trial eligibility determined by the site investigator and local heart team. Complete inclusion and exclusion criteria for REDUCE-FMR have been published previously.[13]

Procedure

Coronary angiography was performed to assess anatomy and exclude contraindications. A 10-F sheath was inserted into the right internal jugular vein for Carillon system delivery. The delivery catheter was advanced into the coronary sinus and quantitative venous angiography was performed to verify the anatomical compatibility of the coronary sinus and great cardiac vein for device deployment. The distal anchor was deployed in the great cardiac vein, tension was applied to reduce the mitral annular dimensions, and left coronary angiography was performed to exclude circumflex artery impingement. The proximal anchor was then positioned and locked in the coronary sinus to maintain tension. After device deployment, transthoracic echocardiography was used to assess the device position and regurgitation severity using color Doppler. All procedures were performed under general anesthesia or conscious sedation.

Outcomes

The primary outcome of this study was 10-year survival following Carillon implantation. Enrollment occurred between March 2015 and July 2017, and vital status was determined using electronic health records, general practitioner contacts, and the French National Death Registry. The final assessment occurred in July 2025, which provided 8-10 years of vital status follow-up for all patients. Secondary outcomes included 10-year cardiovascular survival as well as heart failure hospitalization (HFH) and changes in NYHA class, 6-minute walk test, Kansas City Cardiomyopathy Questionnaire (KCCQ) score, MR grade, regurgitant volume, tent dimension, LV end-diastolic volume, and LV end-systolic volume through 1 year. The minimal clinically important difference (MCID) was defined as a ≥30 meter increase on the 6-minute walk test and a ≥5 point increase on the KCCQ.[21,22] All echocardiograms were interpreted by an independent echocardiography core laboratory using established guidelines.[23,24]

Statistical analysis

Continuous variables are reported as means with standard deviations and categorical variables as counts and percentages. Ten-year survival was analyzed using Kaplan-Meier methods. Given the limited sample size and event numbers, univariable Cox proportional hazards models with Firth's penalized likelihood for rare events were used to estimate the associations between baseline patient characteristics and first-year clinical and echocardiographic parameters with 10-year mortality.[25] Baseline variables were entered as fixed factors, and 1-year clinical and echocardiographic changes were entered as time-dependent covariates. Baseline patient characteristics included in the models included age, sex, NYHA class, 6-minute walk test distance, KCCQ score, MR grade, regurgitant volume, tent dimension, LV ejection fraction, LV end-diastolic volume, LV end-systolic volume, and history of ischemic heart disease, diabetes mellitus, and atrial fibrillation. First-year outcomes included HFH and changes in NYHA class, 6-minute walk test distance, MR grade, regurgitant volume, tent dimension, LV end-diastolic volume, and LV end-systolic volume, with baseline to 1-year change analyzed using the Wilcoxon signed-rank test. The results of the regression models are reported as hazard ratios (HR) with 95% confidence intervals (95% CI). All statistical tests were two-sided, with a p-value of <0.05 considered statistically significant. Statistical analyses were performed using Stata v.19.5 (StataCorp).

Results

Of the 17 patients treated with the Carillon device, the mean age was 74±7 years, 65% were male, 88% had ischemic etiology, and 71% were NYHA class III or IV. Although all patients were diagnosed with ≥ 2+ FMR at baseline, subsequent echocardiography core laboratory analysis graded FMR as 1+ in 35%, 2+ in 41%, and 3+/4+ in 24% (Table 1).

Over 1 year of follow-up, 93% of patients had stable or improved NYHA class, 58% achieved the MCID on the 6-minute walk test, and 50% achieved the MCID on the KCCQ. EROA decreased from baseline, with no other significant changes in echocardiographic measurements. During the first year, 41% were hospitalized for HF, survival was 82%, and CV survival was 87% (Table 2).

Over a median follow-up of 9.2 years (range: 8.0 to 10.3 years), 11 deaths occurred, of which 5 were CV-related (all due to HF progression). Non-cardiovascular causes of death included cancer (n=2), chronic kidney disease (n=1), Alzheimer's disease (n=1), hypovolemia (n=1), and unknown cause (n=1). Kaplan-Meier estimates of survival were 82% at 1 year, 53% at 5 years, and 35% at 10 years, with median survival of 5.6 years (Figure 1). The corresponding CV survival estimates were 87% at 1 year, 66% at 5 years, and 66% at 10 years.

In univariable Cox proportional hazards regression, LV ejection fraction <35% (*vs*. ≥35%) was associated with higher 10-year all-cause mortality (hazard ratio=7.1; 95% CI: 1.4, 36.5; p=0.02). Ten-year survival was 0% for LV ejection fraction <35% *vs*. 50% for LV ejection fraction ≥35%, with median survival of 1.7 *vs*. 7.7 years. No other baseline characteristics were associated with long-term mortality after Carillon implantation. Among first-year outcomes, HFH (HR=8.0; 95% CI: 2.0, 32.1; p=0.004) and decreased tent height (HR=5.1; 95% CI: 1.3, 20.8; p=0.02) were associated with 10-year mortality. Ten-year survival was 0% for patients with first-year HFH *vs*. 60% without HFH (median survival: 1.3 *vs*. 8.7 years), and 0% for those with tent height decrease *vs*. 62% for those with stable or increased tent height (median survival: 2.1 *vs*. 9.5 years). No other first-year outcomes

Table 1. Baseline patient characteristics.

Characteristic*	All patients (n=17)
Demographics	
Age (years)	74±7
Male sex	65% (11/17)
Body mass index, kg/m^2	26±4
Medical and surgery history	
Ischemic cardiomyopathy etiology	88% (15/17)
Myocardial infarction	53% (9/17)
Atrial fibrillation	53% (9/17)
Diabetes mellitus	18% (3/17)
Functional assessment	
NYHA classification	
II	29% (5/17)
III	65% (11/17)
IV	6% (1/17)
6-minute walk test, meters	317±105
KCCQ	48±21
LV parameters**	
LV ejection fraction, %	36±7
LV end-diastolic volume, cc	182±43
LV end-systolic volume, cc	116±33
Mitral valve parameters**	
Regurgitant volume, ml	30±17
Tent height, cm	0.99±0.19
Tent area, cm^2	1.81±0.45
EROA, cm^2	0.22±0.12
MR grade	
1+	35% (6/17)
2+	41% (7/17)
3+	18% (3/17)
4+	6% (1/17)

KCCQ, Kansas City Cardiomyopathy Questionnaire; EROA, effective regurgitant orifice area; LV, left ventricular; MR, mitral regurgitation; NYHA, New York Heart Association. *Values are mean±SD (n) or percentage (n/N). **Values based on echocardiographic core laboratory analysis.

Table 2. Clinical, functional, and echocardiographic 1-year outcomes in patients treated with indirect mitral annuloplasty.

Characteristic*	Outcome
Clinical assessment**	
Survival	82% (SE 9%)
Cardiovascular survival	87% (SE 8%)
Heart failure hospitalization	41% (SE 12%)
Change in functional assessment	
NYHA classification	
Improvement	29% (4/14)
No change	64% (9/14)
Worsening	7% (1/14)
6-minute walk test increase ≥ 30 meters	58% (7/12)
KCCQ increase ≥ 5 points	50% (7/14)
Change in LV parameters***	
LV ejection fraction (%)	0 (-6, 2)
LV end-diastolic volume (cc)	7 (-14, 28)
LV end-systolic volume (cc)	2 (0, 20)
Change in mitral valve parameters	
Regurgitant volume (ml)***	-2 (-12, 4)
Tent height (cm)***	0.00 (-0.09, 0.23)
Tent area (cm^2)***	0.16 (0.02, 0.53)
EROA (cm^2)***	-0.04 (-0.18, 0.01)°
MR grade	
Improvement	38% (5/13)
No change	62% (8/13)
Worsening	0% (0/13)

EROA, effective regurgitant orifice area; KCCQ, Kansas City Cardiomyopathy Questionnaire; LV, left ventricular; MR, mitral regurgitation; NYHA, New York Heart Association; SE, standard error. *Values are percentage (n/N) unless otherwise indicated. **Values represent Kaplan-Meier estimates and SE.***Values reported as median change (interquartile range). °p<0.05 for change from baseline.

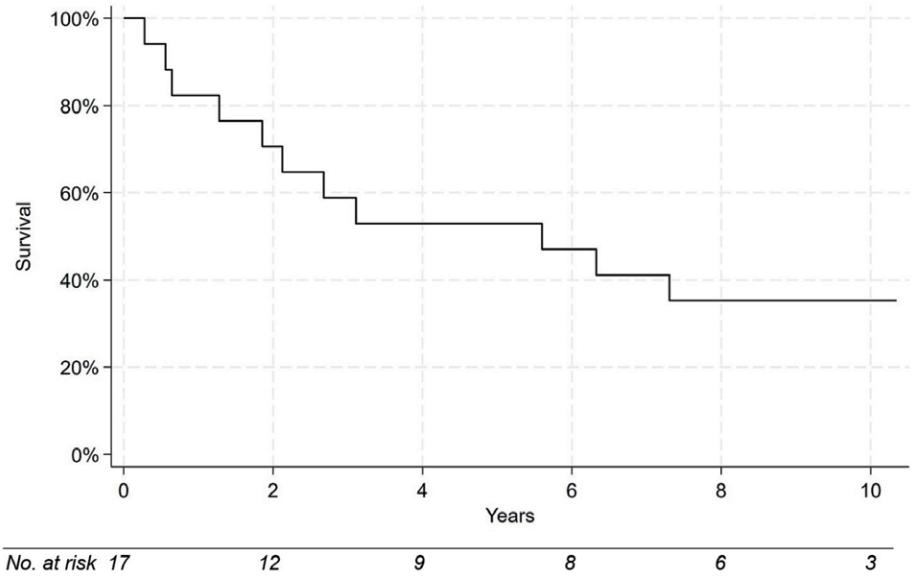

Figure 1. Survival over 10 years in patients treated with indirect mitral annuloplasty (Carillon device).

were associated with long-term mortality (Table 3). First-year HFH was the only variable associated with 10-year CV mortality (HR=9.6; 95% CI: 1.1, 88.8; p=0.046), with median survival of 1.3 *vs*. 9.2 years.

Exploratory analyses showed that all patients with LVEF <35% experienced HFH in the first year, whereas none with LVEF ≥35% experienced a first-year HFH. Ten patients had no HFH in the first year, five patients had one HFH, and two patients had two HFHs. Among those with HFH, the first hospitalization occurred within 3 months in one patient, between 3-6 months in three patients, and between 6 months-1 year in three patients. HFH within 6 months showed a similar association with long-term

Table 3. Association of baseline patient characteristics and 1-year outcomes with 10-year all-cause mortality after indirect mitral annuloplasty.

Variable	Unit of measure*	Hazard ratio**	95% CI	p-value***
Baseline characteristics				
LV ejection fraction	<35% *vs*. ≥ 35%	7.07	1.37, 36.5	0.02
Tent area	≥1.9 *vs*. <1.9 cm^2	2.27	0.65, 7.90	0.20
Sex	Male *vs*. female	2.06	0.54, 7.90	0.29
Diabetes mellitus	No *vs*. yes	2.80	0.36, 21.7	0.33
EROA	≥0.20 *vs*. <0.20 cm^2	1.69	0.51, 5.60	0.39
Age	≥75 *vs*. <75 years	1.57	0.48, 5.19	0.46
Cardiomyopathy etiology	Non-ischemic *vs*. ischemic	1.74	0.37, 8.13	0.48
Regurgitant volume	≥27 *vs*. <27 cc	1.54	0.46, 5.13	0.48
6-minute walk test	<300 *vs*. ≥300 meters	1.51	0.43, 5.26	0.52
LVESV	<112 *vs*. ≥112 cc	1.50	0.40, 5.62	0.55
Body mass index	≤26 *vs*. >26 kg/m^2	1.41	0.43, 4.65	0.57
Tent height	≤0.95 vs. >0.95 cm	1.40	0.40, 4.93	0.60
KCCQ	≥44 *vs*. <44 points	1.36	0.41, 4.47	0.62
MR grade	3/4 *vs*. 1/2	1.39	0.37, 5.29	0.63
NYHA classification	III/IV *vs*. II	1.28	0.34, 4.86	0.71
LVEDV	≥185 *vs*. <185 cc	1.29	0.34, 4.97	0.71
Atrial fibrillation	No *vs*. yes	1.13	0.34, 3.72	0.84
Myocardial infarction	Yes *vs*. no	1.05	0.32, 3.45	0.94

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Table 3. Continued from previous page.

Variable	Unit of measure*	Hazardratio**	95% CI	p-value***
One-year outcomes				
HFH	Yes	7.96	1.97, 32.1	0.004
Tent height	Decrease (change <0 cm)	5.14	1.27, 20.8	0.02
MR grade	No improvement	5.08	0.60, 41.7	0.13
LVESV	Decrease or increase <2 cc	3.46	0.62, 19.2	0.16
Regurgitant volume	Increase (change >0 cc)	2.59	0.51, 13.1	0.25
LV ejection fraction	Increase (change >0%)	2.24	0.40, 12.5	0.36
EROA	Decrease ≥0.04 cm^2	1.85	0.34, 10.2	0.48
NYHA classification	Decrease	1.63	0.39, 6.90	0.50
Tent area	Increase ≥0.15 cm^2	1.31	0.26, 6.51	0.74
6-minute walk test	Decrease or increase <35 meters	1.20	0.24, 5.98	0.82
LVEDV	Decrease or increase <8 cc	1.13	0.22, 5.78	0.89
KCCQ	Decrease or increase <5 points	1.10	0.27, 4.41	0.90

EROA, effective regurgitant orifice area; KCCQ, Kansas City Cardiomyopathy Questionnaire; LV, left ventricular; LVEDV, left ventricular end-diastolic volume; LVESV, left ventricular end-systolic volume; MR, mitral regurgitation; NYHA, New York Heart Association. *Continuous variables dichotomized by the median value. **Hazard ratio >1 indicates higher mortality risk for the specified direction of change in the unit of measure. ***p-values sorted from lowest to highest.

mortality (HR=8.7; 95% CI: 2.0, 37.5; p=0.004) as 1-year HFH. Neither HFH within 3 months nor cumulative HFHs were associated with long-term mortality. Multivariable modeling was not feasible because of the small sample size.

Discussion

In this single-center extension of REDUCE-FMR, 17 patients treated with indirect mitral annuloplasty were followed for nearly a decade, providing the first description of survival beyond 7 years with transcatheter mitral valve repair.[20] Survival over 10 years was 35%, median survival was 5.6 years, and CV survival was 66%. Baseline LV ejection fraction <35% and first-year HFH were the primary indicators of poor long-term prognosis. Overall, this first report of 10-year vital status after indirect mitral annuloplasty shows favorable long-term survival rates and identifies prognostic markers that warrant further investigation in larger cohorts.

The present 5-year survival of 53% and 10-year survival of 35% align with prior Carillon studies and compare favorably with available long-term data from other transcatheter approaches and with GDMT alone. Baseline characteristics in this cohort (mean age 74 years, LVEF 36%, 88% ischemic etiology, and 71% NYHA class III/IV) were comparable to those reported in the TITAN, TITAN II, and REDUCE-FMR trials, as well as contemporary MitraClip studies, which typically enrolled elderly patients with moderate to severe systolic dysfunction and advanced heart failure symptoms. A pooled analysis of TITAN, TITAN II, and REDUCE-FMR reported 56% survival at 5 years with the Carillon device,[14] and a single-site experience reported a 6-year survival rate of 60%.[15] These results also compare favorably with the 22-43% 5- to 7-year survival rates reported with MitraClip and the 33-40% survival observed with GDMT.16-20 The longest known survival follow-up with transcatheter mitral valve repair was the MitraClip study by Geyer et al. who reported 38% survival after 5 years and 22% survival after 7 years.20 These comparisons are descriptive only since differences in patient selection and follow-up methodology prevent formal comparative conclusions. However, no transcatheter mitral device has previously reported survival data beyond 7 years, which makes the current 10-year outcomes informative for understanding treatment durability in this challenging patient population. This sustained benefit with indirect mitral annuloplasty suggests that the favorable survival outcomes observed at 5 years are maintained for a decade post-treatment.

Baseline LV ejection fraction <35% was the strongest predictor of mortality, which is consistent with the literature showing that MR confers a greater prognostic risk in patients with severely reduced systolic function.[26] A large registry similarly identified LV ejection fraction <30% as an independent predictor of long-term mortality after MitraClip,[27] and recent risk stratification models have included LV ejection fraction <40% among the strongest mortality predictors.[28] The association between first-year HFH and poor long-term survival aligns with the COAPT trial results, which demonstrated that HFH is strongly associated with mortality, irrespective of treatment.[29] Together, these observations indicate that advanced HF, which is characterized by severely reduced LV ejection fraction and early HFH, represents a patient subset in which MR treatment may not fully offset the adverse sequelae of advanced LV disease.

The unexpected association between decreased tent height and higher mortality warrants further investigation. Reduced tent height typically signals improved leaflet coaptation and is the mechanistic principle underlying MitraClip therapy. However, in our cohort, it was paradoxically associated with worse long-term survival. This counterintuitive finding may reflect that, in patients with advanced LV disease, early reductions in tenting height may not necessarily indicate durable improvement in valve function but may instead be a marker of progressive adverse remodeling and worsening prognosis. Further, we cannot

exclude the possibility that measurement variability or regression to the mean contributed to this finding. We regard this as hypothesis-generating for confirmation in larger studies. Clinically, patients with severe LV dysfunction and early HFH after indirect mitral annuloplasty may benefit from intensified follow-up, GDMT optimization, and timely consideration of additional interventions to reduce overall HF burden.

Similar to previous data,[30] but unlike the situation for transcatheter edge-edge repair,[31] we were unable to relate baseline natriuretic peptide levels to longer term outcomes. Whether this relates to the specific utility of the Carillon device or is a consequence of limited sample size is unclear, but this finding deserves further investigation in this population to elucidate the relevance of biomarkers in planning catheter-based treatments particularly in those with more severe left ventricular systolic dysfunction.

The primary strength of this study is the determination of 10-year survival rates following Carillon implantation, which represents the longest known follow-up of any percutaneous mitral valve intervention. However, this study had several limitations that must be acknowledged. First, the cohort size of 17 patients provided limited statistical power to identify mortality predictors and precluded multivariable modeling. Second, the single-center design may limit the generalizability of the results to other centers and populations. Third, because this was an observational 10-year extension of the 1-year REDUCE-FMR trial, unmeasured factors beyond 1 year such as subsequent hospitalizations, medication adherence, clinical events, device-related complications, and interventions may have confounded the long-term survival results. Finally, this study enrolled patients with LV ejection fraction <50%; thus, these results may not be applicable to patients with preserved ventricular function. Nevertheless, these novel 10-year survival data should be interpreted in light of sample size, study design, and confounding considerations and, therefore, should be considered preliminary and hypothesis-generating for future studies.

Conclusions

This study provides the first evidence of survival beyond 6 years after indirect mitral annuloplasty with the Carillon device, with 10-year outcomes suggesting durability of this treatment in appropriately selected patients with FMR. Larger studies should build on these encouraging findings.

Contribution to the field

Patients with heart failure often have a leaking mitral valve, which may worsen their symptoms. Medications can help manage these symptoms but do not extend survival, and surgery carries risks for elderly, frail patients. Minimally invasive catheter therapies help fill this gap, but long-term data remain limited. Our study followed 17 patients for 10 years after receiving a device that reduces leakage from the mitral valve, representing the longest follow-up for any similar procedure. Survival was 35 percent at 10 years, which favorably compares to other treatments for this condition.

Conflicts of interest

JL: Consultancy with Cardiac Dimensions. PK: none. LM: Consultancy with Cardiac Dimensions. ND: none.

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Contributions

JL: study oversight; critical review of the manuscript; final approval of the manuscript. PK: data analysis; develop draft of the manuscript; final approval of the manuscript. LM: data analysis; develop draft of the manuscript; final approval of the manuscript. ND: data collection; critical review of the manuscript; final approval of the manuscript.

Data availability statement

The datasets presented in this article are not readily available because they are part of an ongoing study. Requests to access the datasets should be directed to Janusz Lipiecki.

Ethics

Written informed consent was obtained from all participants before REDUCE-FMR trial enrollment, and patients treated at our center provided additional consent for long-term vital status data collection. The ethics review committee of Clinique Pole Sante Republiquee (Clermont-Ferrand, France) approved this study.

References

1. Trichon BH, Felker GM, Shaw LK, et al. Relation of frequency and severity of mitral regurgitation to survival among patients with left ventricular systolic dysfunction and heart failure. Am J Cardiol 2003;91:538-43.
2. Sannino A, Smith RL, Schiattarella GG, et al. Survival and cardiovascular outcomes of patients with secondary mitral regurgitation: a systematic review and meta-analysis. JAMA Cardiol 2017;2:1130-9.

3. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. Circulation 2013;128:e240-327.
4. Yancy CW, Jessup M, Bozkurt B, et al. 2017 ACC/AHA/HFSA focused update of the 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America. Circulation 2017;136: e137-61.
5. Wu AH, Aaronson KD, Bolling SF, et al. Impact of mitral valve annuloplasty on mortality risk in patients with mitral regurgitation and left ventricular systolic dysfunction. J Am Coll Cardiol 2005;45:381-7.
6. Goldstein D, Moskowitz AJ, Gelijns AC, et al. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. N Engl J Med 2016;374:344-53.
7. Lipiecki J, Kuzemczak M. Editorial commentary: functional mitral regurgitation - a moving target in patients with heart failure. Trends Cardiovasc Med 2023;33:393-4.
8. Lipiecki J, Kuzemczak M, Siminiak T. Transcatheter treatment of functional mitral valve regurgitation. Trends Cardiovasc Med 2021;31:487-94.
9. Wołoszyn M, Jerzykowska O, Kałmucki P, et al. Functional assessment of patients after percutaneous mitral valvuloplasty with Carillon device: a preliminary report. Kardiol Pol 2011;69:228-33.
10. Giallauria F, Di Lorenzo A, Parlato A, et al. Individual patient data meta-analysis of the effects of the CARILLON mitral contour system. ESC Heart Fail 2020;7:3383-91.
11. Siminiak T, Wu JC, Haude M, et al. Treatment of functional mitral regurgitation by percutaneous annuloplasty: results of the TITAN trial. Eur J Heart Fail 2012;14:931-8.
12. Lipiecki J, Siminiak T, Sievert H, et al. Coronary sinus-based percutaneous annuloplasty as treatment for functional mitral regurgitation: the TITAN II trial. Open Heart 2016;3 :e000411.
13. Witte KK, Lipiecki J, Siminiak T, et al. The REDUCE-FMR trial: a randomized sham-controlled study of percutaneous mitral annuloplasty in functional mitral regurgitation. JACC Heart Fail 2019;7: 945-55.
14. Lipiecki J, Kaye DM, Witte KK, et al. Long-term survival following transcatheter mitral valve repair: pooled analysis of prospective trials with the Carillon device. Cardiovasc Revasc Med 2020;21:712-6.
15. Lipiecki J, Fahrat H, Monzy S, et al. Long-term prognosis of patients treated by coronary sinus-based percutaneous annuloplasty: single centre experience. ESC Heart Fail 2020;7:3329-35.
16. Stone GW, Abraham WT, Lindenfeld J, et al. Five-year follow-up after transcatheter repair of secondary mitral regurgitation. N Engl J Med 2023;388:2037-48.
17. Kortlandt F, Velu J, Schurer R, et al. Survival after MitraClip treatment compared to surgical and conservative treatment for high-surgical-risk patients with mitral regurgitation. Circ Cardiovasc Interv 2018;11:e005985.
18. Mazzola M, Giannini C, Adamo M, et al. Guideline-directed medical therapy and survival after TEER for secondary mitral regurgitation with right ventricular impairment. JACC Cardiovasc Interv 2024;17: 1455-66.
19. Stocker TJ, Stolz L, Karam N, et al. Long-term outcomes after edge-to-edge repair of secondary mitral regurgitation: 5-year results from the EuroSMR Registry. JACC Cardiovasc Interv 2024;17: 2543-54.
20. Geyer M, Keller K, Born S, et al. Predictors of short- and long-term outcomes of patients undergoing transcatheter mitral valve edge-to-edge repair. Catheter Cardiovasc Interv 2021; 97:E390-401.
21. Shoemaker MJ, Curtis AB, Vangsnes E, et al. Clinically meaningful change estimates for the six-minute walk test and daily activity in individuals with chronic heart failure. Cardiopulm Phys Ther J 2013;24:21-9.
22. Spertus JA, Jones PG, Sandhu AT, et al. Interpreting the Kansas City Cardiomyopathy Questionnaire in clinical trials and clinical care: JACC state-of-the-art review. J Am Coll Cardiol 2020;76:2379-90.
23. Zoghbi WA, Adams D, Bonow RO, et al. Recommendations for noninvasive evaluation of native valvular regurgitation: a report from the American Society of Echocardiography developed in collaboration with the Society for Cardiovascular Magnetic Resonance. J Am Soc Echocardiogr 2017; 30:303-71.
24. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging 2015;16:233-70.
25. Heinze G, Schemper M. A solution to the problem of monotone likelihood in Cox regression. Biometrics 2001;57: 114-9.
26. Pecini R, Thune JJ, Torp-Pedersen C, et al. The relationship between mitral regurgitation and ejection fraction as predictors for the prognosis of patients with heart failure. Eur J Heart Fail 2011;13:1121-5.
27. Kalbacher D, Schafer U, von Bardeleben RS, et al. Long-term outcome, survival and predictors of mortality after MitraClip therapy: results from the German Transcatheter Mitral Valve Interventions (TRAMI) registry. Int J Cardiol 2019;277:35-41.
28. Raposeiras-Roubin S, Adamo M, Freixa X, et al. A score to assess mortality after percutaneous mitral valve repair. J Am Coll Cardiol 2022;79:562-73.
29. Giustino G, Camaj A, Kapadia SR, et al. Hospitalizations and mortality in patients with secondary mitral regurgitation and heart failure: the COAPT trial. J Am Coll Cardiol 2022;80: 1857-68.
30. Siminiak T, Jerzykowska O, Kuzemczak M. B-type natriuretic peptide in patients after percutaneous trans-coronary-sinus mitral annuloplasty. Kardiol Pol 2014;72:446-51.
31. Taramasso M, Maisano F, Latib A. Clinical outcomes of MitraClip for the treatment of functional mitral regurgitation. EuroIntervention 2014;10:746-52.