Published in final edited form as:
Ann Thorac Surg. 2013 March ; 95(3): 787–794. doi:10.1016/j.athoracsur.2012.08.042.

Robotic Posterior Mitral Leaflet Repair: Neochordal versus Resectional Techniques

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Abstract

Background—Resectional techniques are the established method of posterior mitral valve leaflet repair for degenerative disease; however, use of neochordae in a robotically assisted approach is gaining acceptance because of its versatility for difficult multi-segment disease. The purposes of this study were to compare the versatility, safety, and effectiveness of neochordal vs. resectional techniques for robotic posterior mitral leaflet repair.

Methods—From 12/2007 to 7/2010, 334 patients underwent robotic posterior mitral leaflet repair for degenerative disease by a resectional (n=248) or neochordal (n=86) technique. Outcomes were compared unadjusted and after propensity score matching.

Results—Neochordae were more likely to be used than resection in patients with two (28% vs. 13%, P=.002) or three (3.7% vs. 0.87%, P=.08) diseased posterior leaflet segments. Three resection patients (0.98%) but no neochordal patient required reoperation for hemodynamically significant systolic anterior motion (SAM). Residual mitral regurgitation (MR) at hospital discharge was similar for matched neochordal vs. resection patients (P=.14) (MR 0+, 82% vs. 89%; MR 1+, 14% vs. 8.2%; MR 2+, 2.3% vs. 2.6%; one neochordal patient had 4+ MR and was reoperated). Among matched patients, postoperative mortality and morbidity were similarly low.

Conclusion—Compared with a resectional technique, robotic posterior mitral leaflet repair with neochordae is associated with shorter operative times and no occurrence of SAM. The versatility, effectiveness, and safety of this repair make it a good choice for patients with advanced multi-segment disease.

Keywords

mitral regurgitation; mitral systolic anterior motion; minimally invasive; surgery; outcomes

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INTRODUCTION

Resectional techniques have been the established method of posterior mitral leaflet repair for degenerative disease; however, repair in patients with multi-segment disease and those with extensive prolapse and large scallops is more challenging because complete resection of all prolapsed tissue could compromise the integrity of repair and valve function. Therefore, neochordae that allow mitral valve (MV) repair without resection are an attractive alternative [1-4]. Both randomized and observational clinical studies have shown comparable results in repairs using neochordae [5,6], but concerns have been raised regarding technical complexity, operative time, reproducibility, and durability of the neochordal technique.

The purposes of this study were to compare the versatility, effectiveness, and safety of neochordal vs. resectional techniques for robotic posterior mitral leaflet repair in degenerative disease.

PATIENTS AND METHODS

Study Population

From December 2007 (which marks the month of the first robotic use of neochordae in our robotic practice) to July 2010, 443 patients underwent robotic MV repair for degenerative disease. Patients were excluded if neither neochordal nor resectional techniques were used (n=62), if an anterior leaflet procedure was performed (n=46), and if both neochordal and resectional techniques were used for the repair (n=1). Of the 334 remaining patients, 248 (74%) had intended repair with resectional techniques and 86 (26%) with neochordae. Over time, the proportion of repairs using neochordae has increased (Figure 1). All patients received flexible anuloplasty bands with their repairs.

Surgical Technique

Neochordal—For neochordal implantation, we use No. 5-0 polytetrafluoroethylene (PTFE) monofilament suture. A dynamic left atrial retractor is advanced into the left ventricle to lift up the anterior leaflet of the MV, allowing excellent exposure of the subvalvar apparatus (Figure 2). One arm of the PTFE suture is passed through the fibrous tip of the papillary muscle two or three times, then twice through the free edge of the corresponding prolapsed segment of posterior leaflet [7]. The second arm is then passed twice through the free edge of the prolapsed leaflet. Length of the chordae is adjusted based on height of the nearest non-prolapsed posterior leaflet segment [1]. The suture is tied intracorporeally with robotic instrumentation. The repair is completed with an anuloplasty band sutured in a running fashion, as previously described [8].

Resectional—In resectional techniques, MV repair is performed using triangular or quadrangular resection of the prolapsed segment, as previously described [9,10].

Data

Clinical data were obtained from Cleveland Clinic's Cardiovascular Information Registry, a prospective database updated concurrently with patient care. Echocardiography data were obtained from the Cleveland Clinic echocardiography database. Operative details (which segments were diseased, use of neochordal or resectional methods, number of intraoperative repair attempts—meaning that the patient was weaned from cardiopulmonary bypass [CPB] and found by intraoperative transesophageal echocardiography (TEE) to have important residual MR, necessitating return to CPB to address it—and procedures performed during these additional intraoperative repair attempts) were obtained by review of each patient's medical record. Use of these data for research was approved by the Institutional Review Board, with patient consent waived.

Endpoints

Versatility was assessed by the frequency with which neochordae were used for multi-segment disease, number and outcomes of intraoperative repair attempts required to achieve satisfactory repair, conversion to sternotomy, and operative times.

Effectiveness was assessed by residual mitral regurgitation (MR), conversion of intended repair to valve replacement, mitral valve reoperation before hospital discharge, and presence of systolic anterior motion (SAM).

Safety was assessed by in-hospital morbidity and mortality as defined by the Society of Thoracic Surgeons (STS) National Database (http://www.ctsnet.org/file/rptDataSpecifications252_1_ForVendorsPGS.pdf)

Statistical Analysis

Although patient characteristics were generally similar between the two groups (Table 1), we used matching to adjust for remaining differences, revealed in Figures 3 and 4. Using multivariable logistic regression of preoperative variables (Table 1), we identified the preoperative factors associated with having repair using neochordae (parsimonious model). Variable selection used bagging [11]. For this, 1,000 bootstrap samples were analyzed by automated forward stepwise selection, with $P \leq .05$ to retain variables. Variables appearing in 50% or more of the analyses were retained (aggregation step).

To this parsimonious model, we added variables representing groups of patient factors that might be related to unrecorded selection factors (semi-saturated propensity model) [12,13]. A propensity score was calculated for each patient by solving the saturated model for the probability of having a neochordal procedure. Using only the propensity score, all neochordal cases (100%) were matched to resectional cases using a greedy matching strategy [14]. This resulted in well-matched patients across the entire spectrum of propensity scores (see Figures 3 and 4).

Missing values—We used multiple imputation with a Markov Chain Monte Carlo technique to impute the missing covariate values where necessary [15]. Fivefold multiple imputation used PROC MI followed by PROC MI-ANALYZE (SAS v9.1; SAS, Inc., Cary, NC).

Presentation—Continuous variables are summarized by mean ± 1 standard deviation, and as 15th, 50th (median), and 85th percentiles when values are skewed. Comparisons were made using the Wilcoxon rank-sum test. Categorical data are summarized by frequencies and percentages. Comparisons were made using the chi-squared test or Fisher's exact test when frequency was less than 5. All analyses were performed using SAS statistical software (SAS v9.1). Parametric estimates are accompanied by an asymmetric 68% confidence interval, comparable to ±1 standard error.

RESULTS

Versatility

Neochordae were used more frequently than resectional techniques in patients with two or three diseased posterior leaflet segments or a diseased P3 segment (Table 1). In matched and unmatched comparisons in both groups, a similar proportion of patients required multiple intraoperative attempts to achieve satisfactory repair (Table 2). One patient in the neochordae group required conversion to sternotomy. There were no conversions from repair to valve replacement. Anuloplasty band size was significantly larger in the neochordal group (Table 2).

Myocardial ischemic time was shorter for the neochordal group in unmatched comparison, and this difference remained but was statistically insignificant after matching, largely due to decreased population in the matched comparison (Table 2). Cardiopulmonary bypass time was shorter for the neochordal group in both unmatched and matched comparisons (see Table 2).

Effectiveness

All patients had successful repair, and none required MV replacement. Degree (0-4+) of residual MR preceding discharge or MV reoperation was similar after neochordal and resectional repair (Table 3). Postoperative SAM occurred in three patients undergoing resection in the unmatched population (Table 4). One patient in the neochordal group required robotically assisted reoperation for 4+ residual MR due to a linear tear in the anterior mitral leaflet, likely caused by the dynamic left atrial retractor. Four patients who underwent repair with resectional techniques required reoperation early after repair through a complete sternotomy: three for hemodynamically significant left ventricular outflow obstruction due to SAM and one for acute occlusion of the proximal left anterior descending coronary artery, apparently from embolic material in an otherwise normal artery, requiring emergency coronary artery bypass grafting.

Further examination of the 27 patients requiring multiple intraoperative repair attempts shows that they were more likely to have a slightly higher degree of residual MR after surgery than those whose repairs were completed on the first attempt (Table 4). Operations requiring multiple intraoperative repair attempts also had significantly longer myocardial ischemic and CPB times (Table 4). No MV reoperations occurred in the group requiring multiple intraoperative repair attempts.

Safety

There was no in-hospital mortality or occurrence of aortic dissection in either group. Occurrence of postoperative morbid events (as defined by the STS National Database) was similar between unmatched and matched groups (Table 5.

COMMENT

Principal Findings

We found that robotic posterior mitral leaflet repair using neochordae is a <u>versatile</u> technique, particularly for multi-segment disease for which resectional techniques have limited potential. The technique is as <u>effective</u> and <u>safe</u> as resectional methods.

The aim of MV repair is to restore the morphology and function of the native valve. The advantage of MV repair using neochordae is in restoring valve function without decreasing orifice size and creating a transvalvar gradient, as is the occasional case when resectional techniques are used [6]. Neochordal techniques decrease the potential for postoperative SAM by moving the leaflet coaptation point posteriorly, resulting in relative restriction of the posterior leaflet. This was substantiated by observing postoperative SAM only in the resectional group. All patients in the resected group had no or only mild SAM at the end of the operation, documented by intraoperative TEE. Delayed occurrence of SAM early postoperatively most likely reflects decreased left ventricular size and improved left ventricular contractility.

Although posterior MV repair with neochordae has been viewed as technically challenging, we found that operative times in neochordal procedures using the robotic approach were shorter. This can be explained by superior exposure and visualization of the subvalvar MV apparatus by robotic technology, as well as superior handling of robotic instruments. Furthermore, we simplified the chordal implantation technique by using a figure-of-eight suture anchoring into the tip of the papillary muscles, thereby reducing the time-consuming placement of pledget-reinforced anchoring sutures [1].

This study also addressed outcomes of patients requiring multiple intraoperative attempts to achieve MV repair. Nevertheless, these patients all left the hospital with a repair rather than replacement, although with somewhat more residual MR.

Limitations

This is a single-institution clinical study with analysis of outcomes limited to hospital course. Since the Cleveland Clinic first used the robotic approach in 2006, we have had a high volume of robotically assisted MV repairs for posterior leaflet disease. This type of MV operation was reflective of surgeon preference (primarily one surgeon), not standardized and not randomized. To mitigate these limitations, we have used propensity matching for fair comparison with a contemporaneous group of resectional patients. We have used standard Carpentier definitions [7,16] of mitral valve pathology, although we recognize the morphologic heterogeneity of degenerative MV disease [17].

Conclusions

Compared with a resectional technique, robotic posterior mitral leaflet repair with neochordae is associated with shorter operative times and no occurrence of SAM. The versatility, effectiveness, and safety of this repair make it a good choice for patients with advanced multi-segment disease.

Acknowledgments

This study was supported in part by the Kenneth Gee and Paula Shaw, PhD, Chair in Heart Research, held by Dr. Blackstone; and the Peter Boyle Fund for Robotic Cardiac Surgery Research and Donna and Ken Lewis Endowed Chair held by Dr. Mihaljevic. Gregory Pattakos, MD, MS, is a National Heart, Lung and Blood Institute Clinical Research Scholar of the Cardiothoracic Surgical Trials Network, and his master of science in clinical research has been funded by NIH grant 1U01HL088955-01. No sponsor had direct involvement of any kind in this research study.

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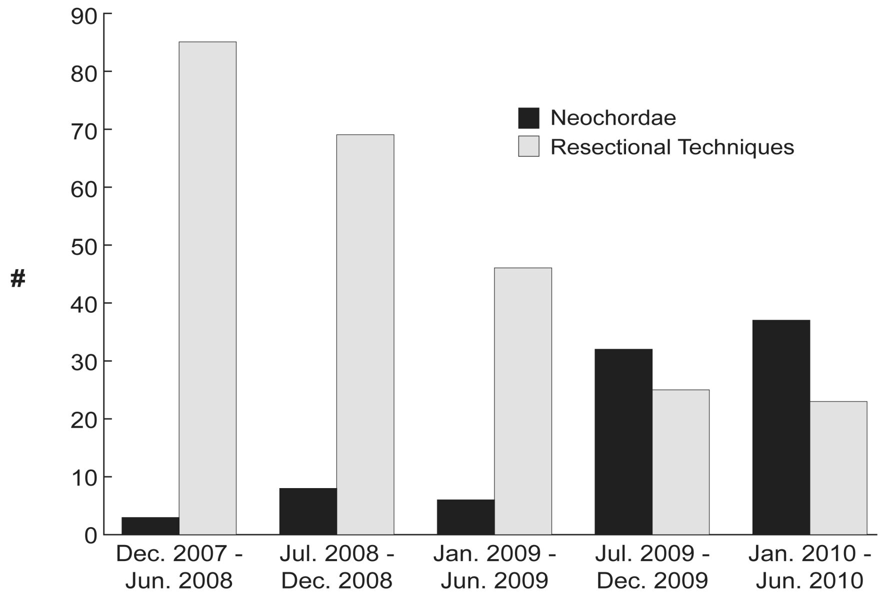

Figure 1.
Temporal trend of neochordae use.

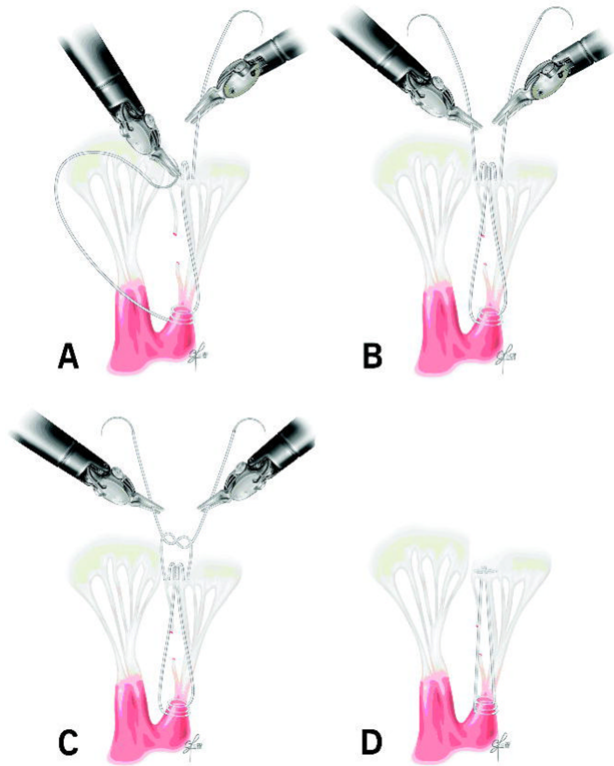

Figure 2.

Posterior neochord implantation: One arm of suture is passed through the fibrous papillary muscle tip two to three times and twice through the free edge of the prolapsed segment. The second arm is passed twice through the free edge of the prolapsed leaflet. The neochord's length is adjusted to the height of the nearest non-prolapsed posterior leaflet segment, and the suture is tied. **A, B:** Figure-of-eight neochordal implantation. **C:** Chordal height adjustment. **D:** Completed neochord.

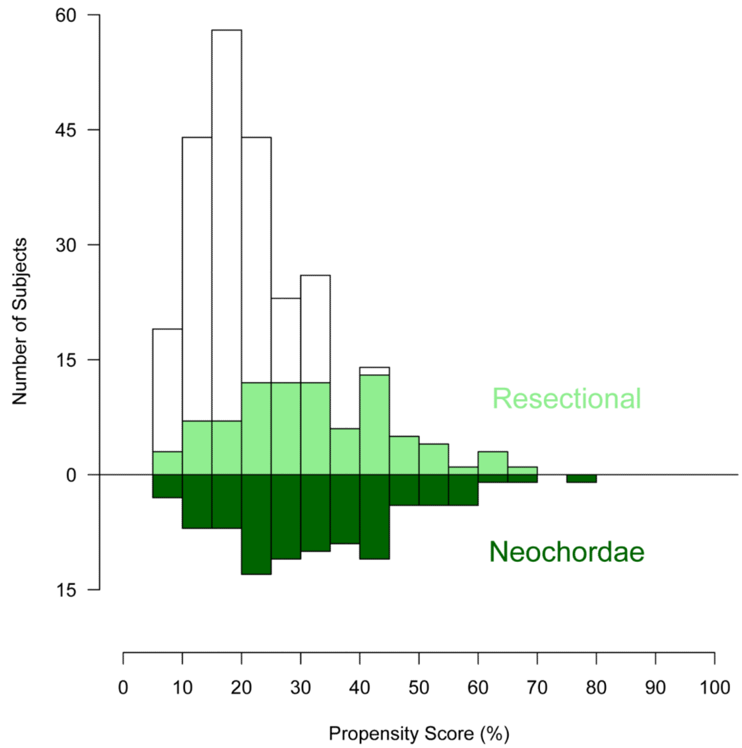

Figure 3.
Mirrored histogram of distribution of propensity scores for resectional (bars above zero line) and neochordal (bars below zero line) approaches. The darkened area represents matched patient pairs, showing that they cover the complete spectrum of cases.

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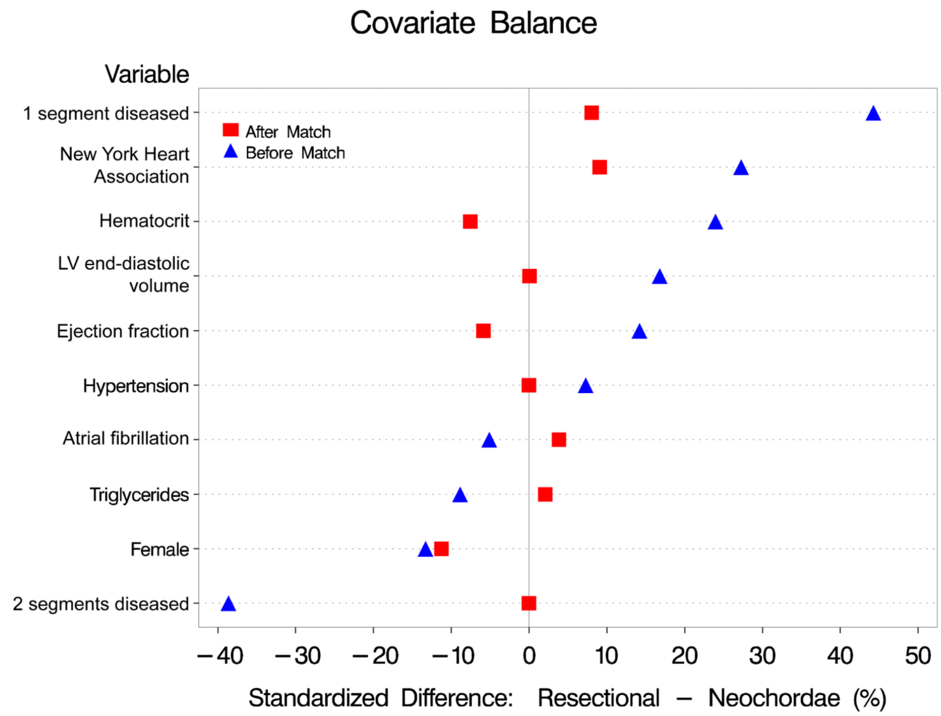

Figure 4.
Covariate balance for some selected variables before and after matching. Values on the horizontal axis represent the percent standardized differences between resectional and neochordal groups.

Table 1

Demographics, Valvar Pathology, and Comorbidity

	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
Variable	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*
Demographics										
Female[b]	248	47 (19)	86	21 (24)	.3	86	17 (20)	86	21 (24)	.5
Age (y)[b]	248	56 ± 9.6	86	57 ± 10	.4	86	56 ± 9.4	86	57 ± 10	.7
Body mass index (kg•m^{-2})[b]	246	26 ± 4.4	86	26 ± 3.4	.8	85	26 ± 4.5	86	26 ± 3.4	.9
Valvar pathology										
Mitral regurgitation grade[b]	242		82		.5	83		82		.6
2+		1 (0.41)		1 (1.2)			0 (0)		1 (1.2)	
3+		42 (17)		11 (13)			12 (14)		11 (13)	
4+		199 (82)		70 (85)			71 (86)		70 (85)	
Tricuspid regurgitation grade		236		79		.8	81	79		.9
None		132 (56)		45 (57)			41 (51)		45 (57)	
1+		74 (31)		22 (28)			27 (33)		22 (28)	
2+		25 (11)		11 (14)			12 (15)		11 (14)	
3+		5 (2.1)		1 (1.3)			1 (1.2)		1 (1.3)	
Segment P1 diseased[b]	227	25 (11)	81	9 (11)	>.9	79	17 (22)	81	9 (11)	.07
Segment P2 diseased[b]	230	217 (94)	81	79 (98)	.2	81	74 (91)	81	79 (98)	.09
Segment P3 diseased[b]	228	22 (9.6)	80	22 (28)	<.0001	80	13 (16)	80	22 (28)	.08
Number of P segments diseased[b]	230		81		.001	81		81		.2
1		198 (86)		55 (68)			58 (72)		55 (68)	
2		30 (13)		23 (28)			23 (28)		23 (28)	
3		2 (0.87)		3 (3.7)			0 (0)		3 (3.7)	
Left atrial diameter (cm)	242	4.6 ± 0.72	81	4.5 ± 0.84	.4	82	4.6 ± 0.66	81	4.5 ± 0.84	.5
Cardiac comorbidity										
Atrial fibrillation/flutter[b]	243	12 (4.9)	82	5 (6.1)	.7	85	6 (7.1)	82	5 (6.1)	.8

	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
Variable	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*
Heart failure	248	13 (5.2)	86	2 (2.3)	.3	86	6 (7.0)	86	2 (2.3)	.15
NYHA functional class[b]	223		74		.14	76		74		.9
I		111 (50)		48 (65)			47 (62)		48 (65)	
II		90 (40)		20 (27)			21 (28)		20 (27)	
III		21 (9.4)		6 (8.1)			8 (11)		6 (8.1)	
IV		1 (0.45)		0 (0)			—		—	
Ejection fraction (%)[b]	241	60 ± 4.1	82	59 ± 4.7	.15	82	59 ± 4.2	82	59 ± 4.7	>.9
Noncardiac comorbidity										
Peripheral arterial disease	248	1 (0.4)	86	0 (0)	.6	86	0 (0)	86	0 (0)	—
Carotid disease	248	14 (5.6)	86	0 (0)	.02	86	4 (4.7)	86	0 (0)	.04
Stroke	248	4 (1.6)	86	0 (0)	.2	86	0 (0)	86	0 (0)	—
Hypertension[b]	248	104 (42)	86	33 (38)	.6	86	33 (38)	86	33 (38)	>.9
Pharmacologically treated diabetes	248	1 (0.4)	86	3 (3.5)	.02	86	1 (1.2)	86	3 (3.5)	.3
Smoking[b]	248	90 (36)	86	26 (30)	.3	86	25 (29)	86	26 (30)	.9
COPD	248	9 (3.6)	86	2 (2.3)	.6	86	2 (2.3)	86	2 (2.3)	>.9
Creatinine (mg•dL^{-1})	248	0.98 ± 0.20	86	0.97 ± 0.19	.4	86	0.96 ± 0.19	86	0.97 ± 0.19	.9
Blood urea nitrogen (mg•dL^{-1})	248	17 ± 4.4	86	17 ± 4.4	.7	86	18 ± 4.5	86	17 ± 4.4	.9

[a]Patients with data available.

[b]Variables used in propensity model. In addition to these, we included preoperative hematocrit, triglycerides, and left ventricular end-diastolic volume and mass.

Key: *COPD,* chronic obstructive pulmonary disease; *NYHA,* New York Heart Association; *SD,* standard deviation.

Table 2

Operative Details

	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
Variable	**n[a]**	**No. (%) or Mean ± SD**	**n[a]**	**No. (%) or Mean ± SD**	***P***	**n[a]**	**No. (%) or Mean ± SD**	**n[a]**	**No. (%) or Mean ± SD**	***P***
Surgeon										
Surgeon A	248	119 (48)	86	82 (95)	<.0001	86	48 (56)	86	82 (95)	<.0001
Neochordae use										
Number of neochordae used	248		80		<.0001	86		80		<.0001
None		248 (100)		0 (0)			86 (100)		0 (0)	
2		0 (0)		41 (51)			0 (0)		41 (51)	
3		0 (0)		33 (41)			0 (0)		33 (41)	
4		0 (0)		4 (5)			0 (0)		4 (5)	
5		0 (0)		2 (2.5)			0 (0)		2 (2.5)	
Chordae to P1	248	0 (0)	82	8 (9.8)	<.0001	86	0 (0)	82	8 (9.8)	.003
Chordae to P2	248	0 (0)	82	80 (98)	<.0001	86	0 (0)	82	80 (98)	<.0001
Chordae to P3	248	0 (0)	82	16 (20)	<.0001	86	0 (0)	82	16 (20)	<.0001
Additional components of repair										
Anuloplasty band size (mm)	246		86		.0009	86		86		.08
28		0 (0)		1 (1.2)			0 (0)		1 (1.2)	
30		3 (1.2)		1 (1.2)			1 (1.2)		1 (1.2)	
32		3 (1.2)		1 (1.2)			0 (0)		1 (1.2)	
33		0 (0)		1 (1.2)			0 (0)		1 (1.2)	
34		47 (19)		9 (10)			16 (19)		9 (10)	
35		0 (0)		1 (1.2)			0 (0)		1 (1.2)	
36		120 (49)		31 (36)			40 (47)		31 (36)	
38		73 (30)		38 (44)			28 (33)		38 (44)	
40		0 (0)		3 (3.5)			0 (0)		3 (3.5)	
Commisuroplasty	248	7 (2.8)	86	8 (9.3)	.01	86	4 (4.7)	86	8 (9.3)	.2
Cleft closure	248	33 (13)	84	15 (18)	.3	86	13 (15)	84	15 (18)	.6

	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
Variable	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*
Folding valvuloplasty	248	26 (10)	86	0 (0)	.002	86	9 (10)	86	0 (0)	.002
Initial edge-to-edge repair	248	2 (0.81)	86	2 (2.3)	.3	86	2 (2.3)	86	2 (2.3)	>.9
Any atrial fibrillation procedure	248	24 (9.7)	86	7 (8.1)	.7	86	9 (10)	86	7 (8.1)	.6
ASD/PFO suture closure	248	27 (11)	86	13 (15)	.3	86	9 (10)	86	13 (15)	.4
Number of intraoperative repair attempts required to achieve satisfactory repair	248		86		.5	86				>.9
1		229 (92)		78 (91)			78 (91)		78 (91)	
2		17 (6.8)		8 (9.3)			8 (9.3)		8 (9.3)	
3		2 (0.8)		0 (0)			0 (0)		0 (0)	
Edge-to-edge repair for post-repair SAM (same operation)	248	6 (2.4)	86	1 (1.2)	.5	86	1 (1.2)	86	1 (1.2)	>.9
Edge-to-edge repair for post-repair remaining MR (same operation)	248	1 (0.4)	86	1 (1.2)	.4	86	1 (1.2)	86	1 (1.2)	>.9
Times										
Myocardial ischemia (min)	248	86 ± 28	86	79 ± 16	.04	86	85 ± 31	86	79 ± 16	.3
Cardiopulmonary bypass (min)	248	119 ± 34	86	106 ± 22	.002	86	118 ± 35	86	106 ± 22	.06

[a]Patients with data available.

Key: *ASD/PFO,* atrial septal defect/patent foramen ovale; *MR,* mitral regurgitation; *SAM,* systolic anterior motion; *SD,* standard deviation.

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Table 3

Effectiveness

	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
Variable	**n[a]**	**No. (%) or Mean ± SD**	**n[a]**	**No. (%) or Mean ± SD**	***P***	**n[a]**	**No. (%) or Mean ± SD**	**n[a]**	**No. (%) or Mean ± SD**	***P***
Residual MR										
Residual MR degree: preceding discharge or MV reoperation	219		76		.14	72		76		.5
0		196 (89)		62 (82)			64 (89)		62 (82)	
1+		18 (8.2)		11 (14)			6 (8.3)		11 (14)	
2+		5 (2.3)		2 (2.6)			2 (2.8)		2 (2.6)	
3+		0 (0)		0 (0)			0 (0)		0 (0)	
4+		0 (0)		1 (1.3)			0 (0)		1 (1.3)	
Systolic Anterior Motion										
SAM detected postoperatively after initial repair	248	3 (1.2)	86	0 (0)	.3	86	0 (0)	86	0 (0)	—
MV Reoperation										
MV reoperation performed during same hospitalization	248	4 (1.6)	86	1 (1.2)	.8	86	1 (1.2)	86	1 (1.2)	>.9

[a]Patients with data available.

Key: *MR,* mitral regurgitation; *MV,* mitral valve; *SAM,* systolic anterior motion; *SD,* standard deviation.

Table 4

Outcomes of Patients Requiring Multiple Intraoperative Repair Attempts Compared with Successful Initial Repair

	Unmatched Group (total n=334)				
	Multiple Intraoperative Repair Attempts (n=27)		Successful Initial Repair (n=307)		
Variable	**n[a]**	**No. (%) or Mean ± SD**	**n[a]**	**No. (%) or Mean ± SD**	***P***
Operative mortality	27	0 (0)	307	0 (0)	—
Permanent stroke	27	1 (3.7)	307	8 (2.6)	.5
Perioperative myocardial infarction	27	0 (0)	307	3 (0.98)	>.9
Renal failure requiring dialysis	27	0 (0)	307	0 (0)	—
Prolonged ventilation (>24 hours)	27	1 (3.7)	307	10 (3.3)	>.9
Septicemia	27	0 (0)	307	0 (0)	—
Atrial fibrillation	25	7 (30)	284	49 (20)	.2
MV reoperation performed during the same hospitalization	27	0 (0)	307	5 (1.6)	>.9
Systolic anterior motion after initial repair	27	0 (0)	307	3 (0.98)	>.9
MV regurgitation degree: preceding discharge or MV reoperation	25		270		.01
0		17 (68)		241 (89)	
1+		6 (24)		23 (8.5)	
2+		2 (8)		5 (1.9)	
3+		0 (0)		0 (0)	
4+		0 (0)		1 (0.37)	
Myocardial ischemic time (min)	27	125 ± 34	307	80 ± 22	<.0001
Cardiopulmonary bypass time (min)	27	164 ± 37.5	307	111 ± 28	<.0001

[a]Patients with data available.

Key: *MV,* mitral valve; *SD,* standard deviation.

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Table 5

Safety

Variable	Unmatched Group (total n=334)					Matched Group (total n=172)				
	Resection (n=248)		Neochordae (n=86)			Resection (n=86)		Neochordae (n=86)		
	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	*P*
Hospital mortality	248	0 (0)	86	0 (0)	—	86	0 (0)	86	0 (0)	—
Permanent stroke	248	8 (3.2)	86	1 (1.2)	.3	86	1 (1.2)	86	1 (1.2)	>.9
Perioperative myocardial infarction	248	2 (0.81)	86	1 (1.2)	.8	86	2 (2.3)	86	1 (1.2)	.6
Renal failure requiring dialysis	248	0 (0)	86	0 (0)	—	86	0 (0)	86	0 (0)	—
Prolonged ventilation (>24 hours)	248	9 (3.6)	86	2 (2.3)	.6	86	1 (1.2)	86	2 (2.3)	.6
Septicemia	248	0 (0)	86	0 (0)	—	86	0 (0)	86	0 (0)	—
Atrial fibrillation (new onset)[b]	232	37 (16)	77	19 (25)	.08	79	13 (16)	77	19 (25)	.2

[a]Patients with data available.

[b]Patients with preoperative atrial fibrillation are not at risk and hence are excluded from number of patients with data available (n=16).

Key: *SD,* standard deviation.