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Original Article

Single versus bilateral chordo-papillary apparatus preservation in mitral valve replacement: a hemodynamic study

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Abstract

Background: It has been postulated that disruption of the mitral valve apparatus at the time of mitral valve replacement (MVR) is a risk factor for postoperative ventricular dysfunction. The aim of this study was to evaluate the effect of single versus bilateral chordo-papillary preservation on the left ventricular function in comparison to no preservation.

Methods: This study was conducted from 2015 to 2018 on sixty patients who had MVR. The patients were classified into group I included 20 patients who underwent MVR with complete excision of the subvalvular chordae and tips of papillary muscles, group II: included 20 patients who underwent MVR with preservation of posterior chordo-papillary apparatus, and group III: included 20 patients who underwent MVR with preservation of both posterior and anterior chordo-papillary apparatus.

Results: There were 20 males (33.3%), and the mean age was 48.76± 8.91 years. Patients in group III were significantly older (37.15 ±4.92, 39.8 ± 5.49, and 57.25 ± 6.93 years in groups I, II, and III, respectively; p< 0.001). The left ventricular end-diastolic (5.40 ±0.34, 4.96 ± 0.43, and 4.44 ± 0.55 mm in group I, II and III, respectively, p<0.001) and end-systolic diameter (4.33 ±0.48, 3.58 ±0.43 and 3.20 ±0.43 mm in group I, II and III; respectively, p<0.001) were significantly reduced in partial and complete preservation groups after 6 months. Left ventricular ejection fraction improved in the bilateral preservation and partial preservation groups after 6 months (45.32 ±9.78, 56.79 ±10.14, and 56.60 ±11.68 % in groups I, II and III respectively, p<0.001). Mechanical ventilation was significantly longer in group I (24.10 ± 6.6, 16.80 ± 5.97, and 15.80 ± 5.24 hours in groups I, II and III, respectively, p<0.001) and the duration of ICU stay was significantly longer in group I (78.65 ± 15.32, 65.40 ± 14.21, and 60.20 ± 12.58 hours in groups I, II and III, respectively, p<0.001).

Conclusion: Preservation of the annulo-papillary continuity may preserve left ventricular geometry and performance. Total preservation of chordae could be superior to partial preservation with better left ventricular remodeling and improvement in the left ventricular functions.

KEYWORDS
Mitral valve replacement; Mitral valve preservation; Left ventricular function

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Introduction

Mitral valve repair is the preferred method for management for mitral valve diseases [1]; however, the repair is not feasible in all patients [2]. Complete excision of the mitral valve apparatus was associated with an increased incidence of low cardiac output and high morbidity and mortality [3]. Subsequently, several strategies were implemented to improve postoperative outcomes, including sub-valvular apparatus preservation (SVP) [4].

The outcomes of complete versus partial preservation of the mitral valve apparatus varied widely in the literature. [5-8]. Lillehei and associates reported lower operative mortality and morbidity with valvular preservation compared to no leaflet preservation [9]. Complete chordal preservation during mitral valve replacement (MVR) may have an advantage through the reduction of the left ventricular size and maintenance of the ejection fraction [10]. Meanwhile, several studies showed equivalent outcomes with complete and partial preservation of the mitral valve apparatus [11].

Therefore, the objective of the current study was to compare the clinical and echocardiographic outcomes after mitral valve replacement with bilateral leaflet preservation, posterior leaflet preservation, and non-leaflet preservation techniques.

Patients and Methods:

Study design and patients

This prospective cohort study recruited 60 consecutive patients who had mitral valve replacement (MVR) between December 2015 and December 2018, at Nasr City Health Insurance Hospital. The Ethical Committees approved the study protocol, and informed consent was obtained from all patients. Patients who had re-operative MVR or MVR for valve endocarditis, and patients with a concomitant procedure (aortic valve replacement, tricuspid valve surgery, coronary artery bypass grafting) were excluded from the study.

There were 20 males (33.3%), and the ages ranged from 28 to 66 years with a mean ± SD of 48.76± 8.91 years. The demographic and clinical profile of the patients is shown in table 1. Patients in group III were significantly older than group I and II, and no statistically significant difference was found between them regarding gender.

All patients presented with dyspnea classified according to the New York Heart Association (NYHA) classification grade III and IV. There is no significant difference between the mean values of NYHA classes in the three groups (p=0.552) (Table 1)

Table 1: Demographic data of the study population grouped according to valve preservation strategy during mitral valve replacement. Categorical data are presented as number and percent and continuous data as mean and standard deviation.

	Group I (n=20)	Group II (n=20)	Group III (n=20)	P-value	P1	P2	P3
Age (years)	37.15 ±4.92	39.8 ± 5.49	57.25 ± 6.93	<0.001	0.157	<0.001	<0.001
Females	14 (70.0%)	15 (75.0%)	11 (55.0%)	0.377	-	-	-
BMI (Kg/m)	1.74 ± 0.09	1.92 ± 0.14	1.95 ± 0.16	<0.001	<0.001	<0.001	0.372
Diabetes mellitus	3 (15.0%)	4 (20.0%)	1 (5.0%)	0.364	-	-	-
Hypertension	3 (15.0%)	4 (20.0%)	2 (10.0%)	0.676		-	-
COPD	1 (5.0%)	2 (10.0%)	2 (10.0%)	0.804	-	-	-
AF	9 (45.0%)	9 (45.0%)	6 (30.0%)	0.535	-	-	-
NYHA class	2.90 ± 0.64	3.10 ± 0.55	3.05 ± 0.61	0.552	-	-	-

AF: atrial fibrillation; BMI: body mass index; COPD: chronic obstructive lung disease, NYHA: New York Heart Association

P1: comparison between group I and III

P2: comparison between group II and III

P3: comparison between group 1 and II

Table 2: The native valve pathology and baseline echocardiographic data in the three groups. (Continuous variables are presented as mean± SD and categorical data as number and percent)

	Group I (n=20)	Group II (n=20)	Group III (n=20)	P-value	P1	P2	P3
Mitral valve pathology							
Mitral stenosis	5 (25.0%)	3 (15 %)	8 (40.0%)				
Mitral regurge	3 (15.0%)	8 (40%)	12 (60.0%)	0.001	0.137	< 0.001	0.001
Mixed lesion	12 (60.0%)	9 (45%)	0				
Rheumatic	18 (90 %)	15 (75%)	8 (40.0%)				
Degenerative	2 (10.0%)	0 (0.0%)	3 (15.0%)	0.070	-	-	-
Prolapse	0	5 (25%)	9 (45.0%)				
Baseline echocardiographic data							
EF (%)	55.90 ± 9.61	59.85 ± 8.07	57.50 ± 9.64	0.394	-	-	-
LVEDD (cm)	5.12 ± 0.34	5.53 ± 0.45	5.63 ± 0.56	0.002	0.008	0.001	0.496
LVESD (cm)	3.76 ± 0.48	3.85 ± 0.45	4.02 ± 0.43	0.193	-	-	-
LVEDV (ml)	125.35 ± 19.22	149.60 ± 28.06	156.85 ± 36.39	0.003	0.010	0.001	0.429
LVESV (ml)	66.40 ± 13.13	67.80 ±11.31	71.35 ± 7.69	0.344	-	-	-
LA diameter (mm)	40.2±11.1	36.2±10.4	40.1±9.1	0.377	-	-	-
ESPAP (mmHg)	54.75 ± 10.06	52.55 ± 9.05	51.50 ± 9.34	0.547	-	-	-

EF: ejection fraction; ESPAP: end-systolic pulmonary artery pressure; LVEDD: left ventricular end-diastolic diameter; LVESD: left ventricular end-systolic diameter; LVEDV: left ventricular end-diastolic volume; LVESV: left ventricular end-systolic volume.

P1: comparison between group I and III
P2: comparison between group II and III
P3: comparison between group 1 and II

Those 60 patients who fulfilled the criteria required for this study and completed six months of follow up were included into three groups according to the surgeons' preference and mitral valve pathology: group I: included 20 patients who underwent MVR with complete excision of the subvalvular chordae and tips of papillary muscles (nonchordal group), group II: included 20 patients who underwent MVR with preservation of posterior chordo-papillary apparatus (posterior chordal), and group III: included 20 patients who underwent MVR with preservation of both posterior and anterior chordo-papillary apparatus (bilateral chordal group). The patients were followed clinically and echocardiography for 6 months postoperatively. Study endpoints were changes in ejection fraction and left ventricle (LV) diameters, and secondary endpoints were the clinical outcomes, duration of mechanical ventilation, intensive care, and hospital stay.

Surgical technique

Mitral valve replacement was performed through a median sternotomy in all patients with moderate hypothermia and antegrade cardioplegia. Cold crystalloid cardioplegia was used in 49 patients (81.6%), warm blood cardioplegia in 8 patients (13.3%), and custodial was used in 3 patients (5%). Surgical exposure of the mitral valve was done through the left atriotomy, and the transseptal approach was used in 5 patients in group I (25%), 4 patients in group II (20%), and 3 patients in group III (15%).

Once it is determined that the mitral valve not repairable due to excessive leaflet calcification, so mitral valve replacement was performed either with or without leaflet preservation. Group I had complete excision of both valve leaflets with the attached chordae and the tips of papillary muscles. Group II had posterior leaflets preservation; the anterior leaflets excised 2 to 3 mm from the annulus by cutting the tip of the papillary muscle together with the attached chordae tendineae. The posterior leaflet may be retained completely along with the attached chordae tendineae. In this case, leaflet tissue folded up into the annulus by placing the valve sutures through the annulus and bringing them through the leading edge of the leaflet tissue. Otherwise, releasing incisions in order to divide the posterior leaflet into 2 to 5 chordo-papillary segments or small wedge resections of the leaflet was performed if the posterior leaflet was thickened and fibrotic to allow implantation of a larger valve. Group III had preservation of both anterior and posterior leaflets. Pledged sutures placed in such a manner that they pass from the atrium to the ventricle.

Statistical Analysis

The statistical analysis was performed using SPSS version 23 (IBM Corp- Chicago- IL, USA). The quantitative data were presented as mean, standard deviations, and ranges, and the qualitative variables were presented as numbers and percentages. The comparison between groups regarding qualitative data was performed using the Chi-square test and/or Fisher exact test when the expected frequency is less than 5. Quantitative data were compared using the One-Way ANOVA test, followed by post hoc analysis using the LSD test. A p-value of less than 0.05 was considered statistically significant.

Results

Preoperative Characteristics

Most patients in groups I and II had mixed mitral valve lesions, while pure mitral regurgitation predominated in group III. Native valve pathology and baseline echocardiographic data are shown in Table 2.

Operative data:

There was no difference in valve type (p= 0.059) or size among groups (p= 0.697). Operative data are presented in Table 3.

Postoperative outcomes

Inotropic support was used in 17 patients in group I (85%), 10 patients in group II (50%), and 8 patients in group III (40%). Postoperative outcomes are presented in Table 4.

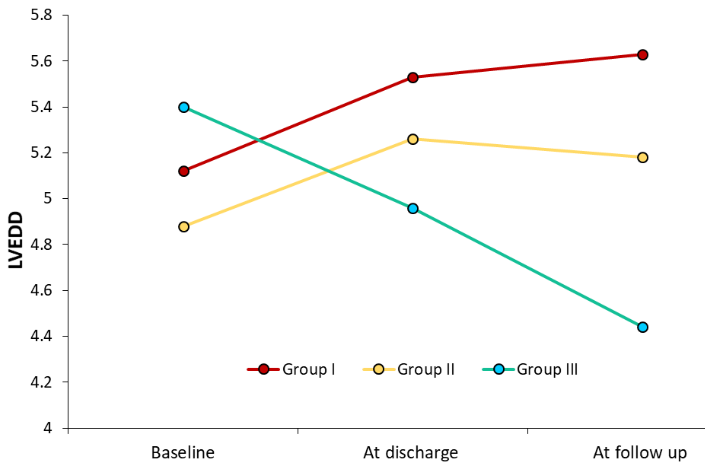

Figure 1: Changes in the left ventricular end-diastolic diameter in the three groups

Postoperative echocardiographic data

The MV prostheses for the 60 patients were all well-functioning with no valvular or para-valvular leakage. The results showed that the LV diastolic diameters were reduced significantly in the three groups in the immediate postoperative period (4.88 ±0.41, 5.26 ±0.43, and 5.18 ±0.56 cm in groups I, II and III, respectively, p= 0.039) and at 6 months follow-up (5.40 ±0.34, 4.96 ± 0.43, and 4.44 ± 0.55 cm in group I, II and III, respectively, p<0.001) (Figure 1).

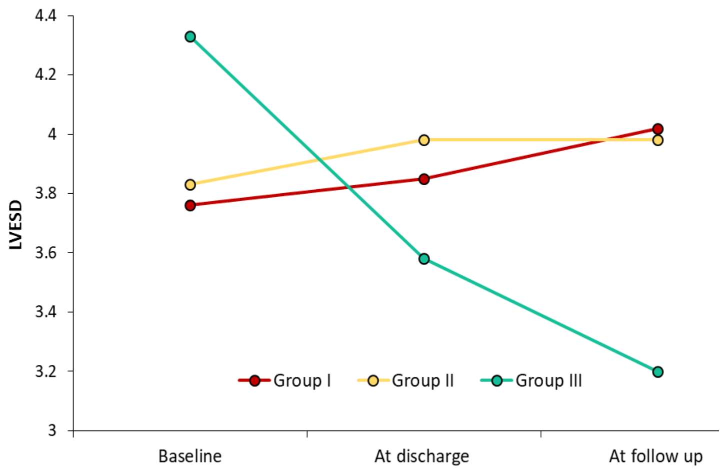

Figure 2: Changes in the left ventricular systolic diameter in three groups at different times

Group I showed a significant increase in systolic diameters immediate postoperative period (3.83 ±0.47, 3.98 ±0.43, and 3.98 ±0.38 cm in group I, II, and III, respectively, p=0.435). At 6 months follow up, a slight decline in systolic and diastolic diameters were noted. Group III showed a significant decrease in systolic diameters at the 6 months follow-up (4.33 ±0.48, 3.58 ±0.43, and

3.20 ±0.43 cm in group I, II and III, respectively, p<0.001) (Figure 2).

The ejection fraction (LVEF) was reduced in the three groups in the early postoperative period (47.58 ±8.92, 52.05 ±10.51, and 49.80 ±8.72 % in group I, II and III, respectively, p= 0.348). In group I, there was progressive deterioration in LVEF, while in group II, the LV function maintained a steady course and failed to improve. In group III, gradual and remarkable improvements were noticed to reach preoperative values at 6-month studies (45.32 ±9.78, 56.79 ±10.14, and 56.60 ±11.68 % in group I, II and III respectively, p<0.001) (Figure 3).

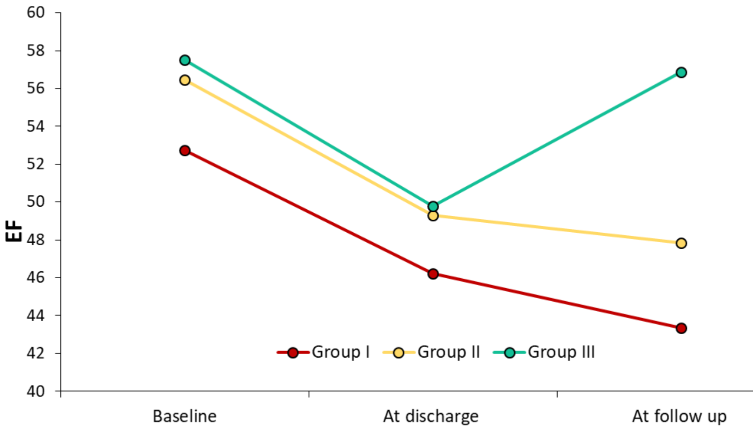

Figure 3: Ejection fraction in three groups at different times.

Discussion

Many studies were published and revealed that the total leaflet preservation was superior to the standard MVR method [12, 13]. Currently, posterior leaflet preservation is the commonly used approach. Despite the good results achieved by the total preservation technique, the technique is more demanding and not routinely used by many surgeons [14, 15].

In our study, patients who had subvalvular apparatus, preservation had longer cross-clamp times and total bypass time. Patients in the preservation groups had unsuccessful trials of repair before undergoing replacement, and this may explain the longer cross-clamp times. Other studies reported the same findings [16, 17].

The implanted prostheses in the three groups were comparable, and the mean valve size was 29.4 ± 1.79 in group I, 29.3 ± 1.97 in group II, and 28.8 ± 1.82 in group III. An argument against the preservation of the anterior leaflet was that only undersized valve prosthesis could be implanted. However, in our study, there was an insignificant difference between bilateral and posterior preservation groups, suggesting that preservation of the anterior mitral leaflet did not preclude implantation of a large prosthesis. Garcia-Fuster and colleagues reported similar prostheses sizes implanted [18]. Our results are in agreement with Zakai and associates who reported insignificant differences in the implanted prostheses sizes between no preservation and total preservation group [19].

In our study, we reported two patients in the total chordal group who had mechanical prosthesis insertion, and the limited movement of the leaflets was observed intra-operatively and was fixed immediately with rotating the valve to a position that allowed free smooth movement of both leaflets. We observed that patients in the preservation groups had shorter ventilation time and ICU and hospital stay. This can be explained by a lesser need for inotropes.

Table 3: Comparison of the operative data, valve size, and type used in the three groups. (Continuous variables are presented as mean± SD and categorical data as number and percent)

	Group I (n=20)	Group II (n=20)	Group III (n=20)	P-value	P1	P2	P3
Mechanical valve	20 (100.0%)	19 (95.0%)	15 (80.0%)	0.059	-	-	-
Cross-clamp time (mins)	58.50 ± 6.24	57.70 ± 6.45	63.30 ± 4.45	0.007	0.663	0.011	0.003
Total bypass time (mins)	72.80 ± 6.88	70.80 ± 4.94	82.05 ± 5.88	<0.001	0.292	<0.001	<0.001

P1: comparison between group I and III
P2: comparison between group II and III
P3: comparison between group 1 and II

Table 4: Comparison of the early postoperative variables among groups. (Continuous variables are presented as mean± SD and categorical variables as number and percent)

	Group I (n=20)	Group II (n=20)	Group III(n=20)	P-value	P1	P2	P3
MV period	24.10 ± 6.61	16.80 ± 5.97	15.80 ± 5.24	<0.001	0.000	0.000	0.598
ICU stay	78.65 ± 15.32	65.40 ± 14.21	60.20 ± 12.58	<0.001	0.004	0.000	0.248
Low CO syndrome	9 (45.0%)	6 (30.0%)	3 (15.0%)	0.117	-	-	-
Inotropic support	17 (85.0%)	10 (50.0%)	8 (40.0%)	0.010	0.018	0.003	0.525
Stroke	1 (5.0%)	1 (5.0%)	0 (0.0%)	0.596	-	-	-
Pacemaker	4(20.0%)	3 (15.0%)	2 (10.0%)	0.676			
Re-exploration	4 (20.0%)	2 (10.0%)	2 (10.0%)	0.562	-	-	-
Mediastinitis	1 (5.0%)	1 (5.0%)	1 (5.0%)	>0.99	-	-	-
Ventilation >48 H	9 (45.0%)	5 (25.0%)	2 (10.0%)	0.043	0.184	0.013	0.211
Mortality	2 (10.0%)	1 (5.0%)	0 (0.0%)	0.349	-	-	-
Hospital stays	19.30 ± 6.42	16.20 ± 2.78	15.00 ± 2.97	0.009	0.029	0.003	0.391

CO: cardiac output; ICU: intensive care unit; MV: mechanical ventilation
P1: comparison between group I and III
P2: comparison between group II and III
P3: comparison between group 1 and II

The preoperative studies showed patients in the preservation group had greater diameters and volumes, which had significant and gradual remodeling at discharge and later studies. In the non-preservation group, there was an initial regression in LVEDD with a significant increase in the LVESD. At later follow-ups, gradual raises in both systolic and diastolic volumes and diameters were noted. Kayagioglu and colleagues reported that the LVEDD and LVESD decreased in the preservation group and increased in the nonchordal group postoperatively, but the changes were insignificant [20].

By analysis of variance, the degree of reduction was more in bileaflet preservation group than the posterior preservation group. In the partial preservation group, immediate reductions were noted in LVEDV. At later studies, a steady course was noted with a slight decline in systolic and diastolic diameters. Yun and associates suggested that preserving all subvalvular apparatus resulted in more reductions in the LVESV and LVEDV with more favorable LV geometry [7].

In our study, there was a significant reduction in the LVEF immediately after surgery in the three groups. Total resection of chordae was associated with further reductions at 6 months follow-up. In the meta-analysis by Sa and colleagues, they concluded that there was more incidence of postoperative low cardiac output syndrome due to lower LVEF in the resection group than in the preservation group [21].

In our study, we reported significant reductions after partial or total preservation of the mitral valve apparatus with a significant superiority of total preservation over partial preservation on the systolic LVEF at 6 months follow-up, which indicates the important effect of the anterior MV leaflet on the LV function. In the meta-analysis by Sa and colleagues, they failed to show any significant advantage of the total over posterior preservation. However, there are many limitations in this meta-analysis; only 2 studies were randomized while 6 studies were non-randomized, even the randomized trials did not mention their mode of randomization and how blind they were; additionally, there was heterogeneity in the techniques of preservation of the anterior and/or the posterior leaflets which would influence the results [21].

Study limitations

The limitations of the study include the sample size, which is not sufficient to detect the difference in clinical outcomes; however, the study identified the difference in the primary echocardiographic endpoints. Another limitation is the single-center experience, and generalization of the results may be an issue. The patients were assigned to each group according to the surgeons' preference and the feasibility of preservation; therefore, the measured and unmeasured patients' characters may not be equally distributed, and the outcome may have been affected by other factors.

Conclusion

Preservation of the annulo-papillary continuity may preserve the left ventricular geometry and performance. Total preservation of chordae could be superior to partial preservation with better LV remodeling and improvement in the LV functions. Preservation of the anterior leaflet may have no effect on the choice of the prosthetic size, left ventricular outflow tract obstruction or interference with prosthetic leaflets motion.

Conflict of interest: Authors declare no conflict of interest.

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