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Original Article

Others Section

Benefits of Posterior Leaflet Preservation in Patients undergoing Mitral Valve Replacement Surgery: A Prospective Interventional Study

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ABSTRACT

Introduction: Mitral Valve Replacement (MVR), an important treatment for rheumatic mitral valve disease, is being widely promoted worldwide. MVR using the total leaflet preservation technique can produce good results; however, patient-specific factors and anatomical considerations must be taken into account when selecting the appropriate surgical approach.

Aim: To investigate the benefits of Posterior Leaflet Preservation (PLP) in MVR in individuals with severe mitral stenosis.

Materials and Methods: The current prospective interventional study included patients with Rheumatic Heart Disease (RHD) who had severe mitral valve stenosis and/or regurgitation and underwent MVR between December 2019 and December 2021 in the Department of Cardiothoracic and Vascular Surgery at Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India. The study included 50 patients with MVR (PLP) to preserve the posterior leaflets and 50 patients with classic MVR (no PLP). Left Ventricular Ejection Fraction (LVEF), Left Ventricular End-Systolic Diameter (LVESD), and Left Ventricular End-Diastolic Diameter (LVEDD) were measured before surgery, one, three, and six months after surgery.

Results: The majority of patients in the present study were between 23 and 46 years old. The PLP group consisted of 17 men and 33 women, while the non-PLP group had 16 men and 34 women. The difference in cross-clamp time between Group-A and B was significant (p=0.0001). Cardiopulmonary Bypass (CPB) time was significantly different between Group-A and B (p=0.001). Only 4 (8%) patients in Group-A had low cardiac output syndrome, compared with 8 (16%) of patients in Group-B. Comparison of LVEF between groups over time revealed no significant difference (p=0.05). The mean change in LVEF from pre-operative to six months in Group-A was significant (p=0.004), but there was no significant change in Group-B (p=0.25).

Conclusion: PLP had no improved beneficial outcome on left ventricular performance in cases with rheumatic stenosis during the six-month follow-up. Even after long-term follow-up, haemodynamic valve properties do not alter with adequate PLP.

Keywords: Chordal preservation, Heart ventricles, Mitral valve insufficiency, Rheumatic valve stenosis

INTRODUCTION

Streptococcus pyogenes infection causes Rheumatic Fever (RF) in untreated, susceptible children and adolescents, due to a delayed and inappropriate immune response [1]. The most common consequence is RHD, which is characterised by valvular lesions that can lead to stenosis and/or insufficiency, particularly in the mitral and aortic valves. Replacing the mitral valve while preserving the sub-valvular apparatus has the advantage of preserving the geometry and function of the Left Ventricle (LV). However, in patients with severe mitral valve stenosis with thickened, fibrosed, and calcified sub valvular apparatus and valve leaflets, this technique usually encounters great difficulty [1,2].

Modified total Leaflet Preservation (MLP), PLP, chordae, and papillary muscle preservation for preserving the valve leaflets have been described, but complete preservation is often limited by many factors such as being technically more difficult, persistent pathological processes in the native valve, longer operative time, the need for a smaller valve prosthesis, obstruction of the left ventricular outflow tract, and concerns about interference with movement of the prosthetic leaflets to the sub-valvular apparatus [2,3]. Therefore, in such cases, most surgeons either completely remove the valve leaflets and the inferior valve apparatus or try to preserve only the posterior valve leaflets. In most of the research comparing leaflet preservation during MVR with standard valve excision during MVR, mitral regurgitation is the primary lesion, and leaflet preservation is not reported in rheumatic patients with fibrosis and calcification [4,5].

PLP during MVR surgery has been shown to have several benefits. Studies suggest that this technique may result in improved post-operative left ventricular function compared to classic MVR [6-8]. In particular, preservation of the Posterior Mitral Leaflet (PML) may be easier and allow implantation of an ideal valve size without compromising the function of the prosthetic valve [6]. In addition, it has been associated with better LVEF and a lower incidence of low cardiac output syndrome in the short term [7]. Additionally, preservation of the posterior leaflet may result in better long-term left ventricular function during exercise, which is critical to the patient's overall cardiac health. Compared to classic MVR, this method can reduce the incidence of low cardiac output syndrome in the short term [8].

Various studies have examined the benefits of preserving the PLP [6,9,10]. A study by Goor DA et al., detailed the results of PLP during mechanical valve replacement for ischaemic mitral regurgitation and highlighted improved survival rates and cardiac function [10]. Guo Y et al., compared MLP, PLP, and techniques without leaflet preservation and concluded that MLP showed better results in the short term [6]. Ozdemir AC et al., highlighted the preference for PLP over bi-leaflet preservation due to the technical simplicity and lower risk of complications [9]. However, there is a lack of long-term data comparing the survival and quality of life outcomes of different leaflet preservation techniques. The effects of PLP on specific subgroups of patients, such as those with rheumatic mitral valve stenosis, are not well documented.

Hence, the present study was conducted to investigate the benefits of PLP in MVR in individuals with severe mitral stenosis. Before surgery, measurements of LVEF, LVESD, and LVEDD were taken at one, three, and six months later.

MATERIALS AND METHODS

The current prospective interventional study was conducted at the Department of Cardiothoracic and Vascular Surgery, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India, from December 2019 to December 2021. The study was approved by the institutional ethics committee, and all patients provided written informed consent before surgery (Ethical clearance number IEC 71/19).

Inclusion criteria: All patients with RHD who had severe mitral stenosis and/or regurgitation and underwent MVR within the study duration. The diagnosis of RHD with severe mitral stenosis and/or regurgitation in patients undergoing MVR was made according to the criteria established by the World Heart Federation (WHF).

Exclusion criteria: Those patients with coronary artery disease, multi-valvular lesions, incisions other than median sternotomy, and repeat procedures were excluded from the study.

Sample size: Power analysis was performed to determine the sample size, and based on a previous study, the sample size was set at 50 in each group [8].

Procedure

Echocardiographic examination of all included participants evaluated valve leaflet mobility, valve thickening, subvalvular thickening, valve calcification, commissural morphology, and leaflet displacement. A clinical examination was also performed to determine symptoms and the presence of a heart murmur suggestive of mitral stenosis or regurgitation [11].

Severity assessment: The criteria outlined by the American Society of Echocardiography (ECHO) were used for the assessment of the degree of regurgitation or stenosis. Valvular regurgitation severity, aortic regurgitation severity, and aortic stenosis were assessed based on peak velocity, mean pressure gradient, and aortic valve area, with a focus on concordance among these measurements. Discordant grading was addressed with specific guidelines [12,13].

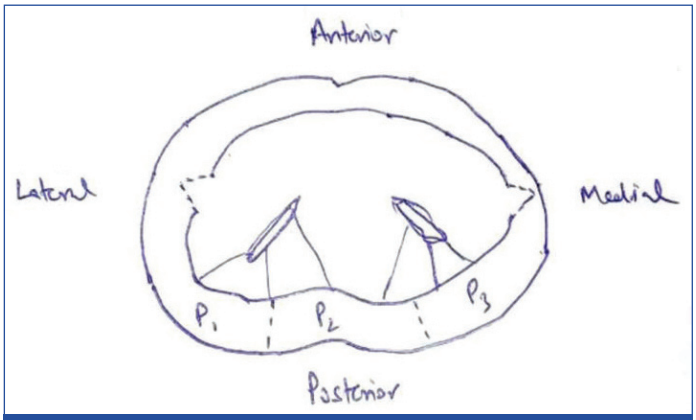
The patients were divided into two groups:

- **Group A-** 50 patients with MVR (PLP) to preserve the posterior leaflets.
- **Group B-** 50 patients with classic MVR (no PLP).

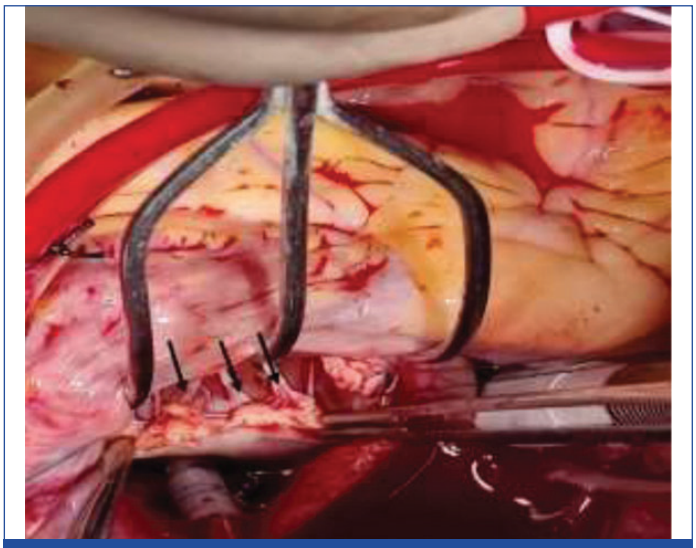
The surgical procedures were decided by operation after examining the anatomy and function of the mitral valve. The Wilkins score of these patients was ≥12 for all patients in both groups [14].

Data collection: Pre-operative data were collected, including diagnosis, cardiac function (New York Heart Association, NYHA, grade) [14], LVEDD, LVESD, and LVEF. Peri-operative data on clamping time, CPB time, recovery time, and early post-operative complications were also recorded during intensive care unit stay. LVEDD, LVESD, and LVEF were assessed in each patient at 1 month, 3 months, and 6-month follow-up using Doppler ECHO. Bleeding, low cardiac output syndrome, post-operative pneumonia, and renal failure were recorded during post-operative intensive care stay.

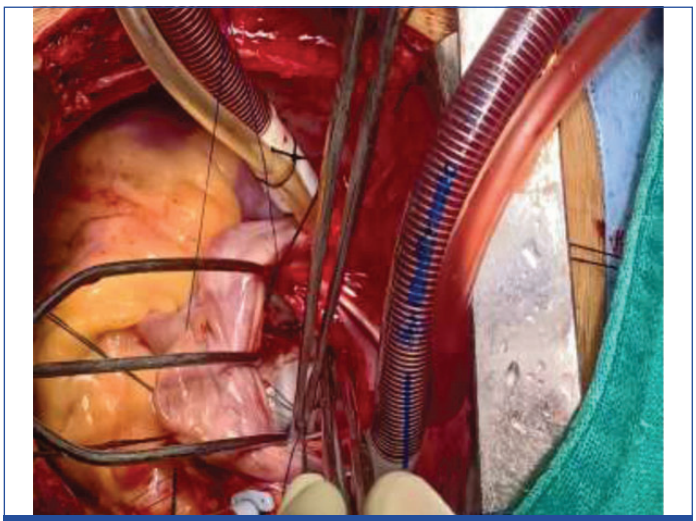
Surgical technique: Three surgeons performed all operations. Operations were performed using CPB, moderate hypothermia (28-32°C), and preliminary cardioplegic cold blood arrest. After cardiac arrest, ice was placed in the pericardium. The mitral valve was accessed through a standard longitudinal incision of the left atriotomy parallel to the inter-atrial groove. After antero-lateral and postero-medial commissurotomy, the anterior leaflet was completely removed with the attached chordae. A decision was made as to whether preservation of the posterior leaflet was possible or not, at the discretion of the surgeon. The thickened part of the posterior leaflets was scraped along the edge of the leaflet and segmented into P1, P2, and P3 and further segments according to the attached chordae tendineae. For calcified posterior leaflets, complete excision of the leaflets was performed. The incision line on the leaflet to divide it into segments was such that the posterior annulus was visible from the ventricular side [Table/Fig-1-3]. Transthoracic Doppler ECHO was performed at one month, three months, and six months. During ECHO evaluation, LVEF, end-diastolic diameter, and end-systolic diameter were measured and analysed [6].



[Table/Fig-1]: Division of posterior leaflet in multiple segments after antero-lateral and postero-medial commissurotomy.



[Table/Fig-2]: Posterior leaflet chordal preservation in Mitral Valve Replacement (MVR).



[Table/Fig-3]: Mitral Valve Replacement (MVR) without posterior leaflet chordal preservation.

STATISTICAL ANALYSIS

Results were presented as frequencies, percentages, and mean Standard Deviation (SD). Continuous data were expressed as mean±SD and compared using one-way analysis of variance, unpaired t-test as appropriate. Within each group, paired t-test was used to compare the mean change in several parameters before and after surgery. A p-value of 0.05 was considered significant. The

Statistical Package for Social Sciences (SPSS) 16.0 (Chicago, Inc., USA) was used in each analysis.

RESULTS

In the present study, the majority of patients were between 23 and 46 years old, with only a few older than 45 years. The PLP group consisted of 17 men and 33 women, while in the non-PLP group, there were 16 men and 34 women. Preoperative NYHA, LVEDD, LVESD, and LVEF (%) were comparable between groups. The difference in cross-clamp time between Group A and B was statistically significant (p=0.0001). CPB time was also statistically different between Group A and B (p=0.001) [Table/Fig-4].

Variable	Group-A	Group-B	p-value*
Age (years)	34.76±12.82	34.68±11.05	0.973
Sex (Male/Female)	17/33	16/34	0.831
Body surface area (m²)	1.50±12	1.57±12	0.093
Diagnosis			
MS	27	33	0.121
MS+MI	23	17	
Cardiac function (NYHA)			
I	0	0	0.091
II	32	34	
III	12	9	
IV	6	7	
LVEDD (mm) preop	47.80±10.87	47.92±10.16	0.954
LVESD (mm) preop	37.88±10.37	38.66±9.48	0.698
LVEF (%) preop	55.08±5.67	55.34±5.05	0.883
Cross clamp time (minutes)	90.02±17.41	56.68±5.64	**0.0001**
CPB time (minutes)	102±4.59	58.69±4.64	**0.001**

[Table/Fig-4]: Clinical profile of the patients.
MS: Mitral stenosis; MR: Mitral regurgitation; LVEDD: Left ventricular end diastolic diameter; LVESD: Left ventricular end-systolic diameter; LVEF: Left ventricular ejection fraction; CPB: Cardiopulmonary bypass. P-value was calculated using test and one-way analysis of variance

After a follow-up period of six months, the mortality rate was zero. Neither infective endocarditis nor dysfunction of the artificial valve occurred in either group. Only 4 (8.0%) of patients in Group A had low cardiac output syndrome, compared with 8 (16.0%) of patients in Group B [Table/Fig-5]. There were no significant (p=0.653) differences in LVEDD between groups over time, but there was a significant (p=0.001) mean change in LVEDD in Group A from pre-operative to 3 and 6 months. There was also a significant (p=0.001) mean change in LVEDD from pre-operative to 6 months in Group B.

Variables	Group-A	Group-B	p-value*
Bleeding	4	3	0.232
Low cardiac output syndrome	4	8	**0.022**
Post op pneumonia	5	4	0.177
Renal failure	2	1	0.111
Death	0	0	-

[Table/Fig-5]: Post-operative complications of the patients.
*p-value between the group was calculated using the chi-square test

At follow-up, there were no statistically significant differences in LVESD between the two groups (p>0.05). However, in Group A, there was a significant mean change in LVESD from preoperatively to three months (p=0.004) and six months (p=0.0001). In Group B, there was no significant mean change in LVESD from pre-operative to three and six months (p=0.05). Comparison of LVEF between groups over time revealed no significant difference (p=0.05). The mean change in LVEF from pre-operative to six months in Group A was significant (p=0.004), but there was no significant change in Group B (p>0.05) [Table/Fig-6].

DISCUSSION

Although the incidence of RHD is declining in most wealthy countries, it remains an endemic disease [15]. Due to their progressive nature and various structural abnormalities (fibrosis, tissue scarring, and calcification), most cardiac surgeons find rheumatic diseases challenging to perform. Few studies have compared the overall survival rate associated with this surgery [16-18]. Chowdhury UK et al., compared three chordal preservation groups (no preservation, posterior leaflet only, and whole) in 451 patients with rheumatic involvement and found that the chordae preservation groups had significantly improved LV function both early and late after surgery as well as higher late survival (after 96 months) [19]. In addition, the researchers found that posterior preservation or no preservation at all resulted in a smaller fractional change in left systolic volume than full preservation, resulting in a greater absolute change.

They concluded that full conservation should be achieved whenever technically possible, with the publication of positive results with the PLP technique [20]. Successive studies demonstrated that the anterior leaflet and sub-valvular tissue are equally important in protecting left ventricular function [8,21-23]. Yun KL et al., found no difference in LV diameter or LVEF between the two treatments in their study [24]. AL Saddique's AA method of preserving entire leaflets had two major disadvantages: first, the preserved tissue was huge because the leaflet was reattached to the annulus after the annulus was cut out from the center and trimmed, and second, the treatment was only performed on patients with mitral regurgitation [25].

In this study, more than half of the patients in both the PLP group (66%) and the non-PLP group (68%) were female. There was no statistically significant gender difference (p=0.831) between the groups, indicating gender equality. Venkatavijay V et al., found that out of 50 hospital patients who underwent surgery, 34 were female, accounting for 68% of the patients, and 16 were male, accounting for 32% of the patients [26].

In the current study, there was no significant (p=>0.954) variation in LVEDD across time periods between the groups. There was a significant difference in the mean change in LVEDD with PLP from pre-operative to three and six months. In patients without PLP, there was a significant (p=0.001) mean change in LVEDD between the pre-operative and six months.

Similar to the present study findings, Guo Y et al., and Kisamori E et al., reported no significant change in postoperative LVEDD [6,27]. Kisamori E et al., reported that there was no significant change in the end-systolic diameter of the LV. In this study, there was no significant (p>0.05) variation in LVEF between the groups over time. The mean LVEF changed significantly from preoperative to six months (p=0.004). Nevertheless, there was no significant (p>0.05) mean change in LVEF from the preoperative to six months

Time period	Preoperatively	1 month	3 months	6 months	p-value	p-value	p-value
					(1 vs 3 months)	(1 vs 6 months)	(3 vs 6 months)
Left ventricular end diastolic diameter (mm)							
Group-A	47.80±10.87	47.70±10.81	47.52±10.77	46.56±10.60	0.951	0.871	0.763
Group-B	47.92±10.16	47.90±10.01	47.86±9.98	47.20±9.96	0.944	0.864	0.741
Mean change Group-A		0.10±0.10	0.18±0.04	0.96±0.17	**0.001**	**0.001**	**0.001**
Mean change Group-B		0.02±0.15	0.04±0.03	0.66±0.02	0.081	**0.001**	**0.001**

Left ventricular end systolic diameter (mm)							
Group-A	37.88±10.37	37.84±10.33	37.42±10.28	36.22±9.97	0.684	0.553	0.253
Group-B	38.66±9.48	38.60±9.44	38.60±9.33	38.42±9.29	0.656	0.503	0.242
Mean change Group-A		0.04±0.04	0.42±0.05	1.20±0.31	0.232	**0.004**	**0.001**
Mean change Group-B		0.06±0.04	0.00±0.11	0.18±0.04	0.241	0.181	0.07
Left Ventricular Ejection Fraction (LVEF)							
Group-A	55.08±5.67	55.01±5.60	54.95±5.55	52.46±5.50	0.831	0.822	0.343
Group-B	55.34±5.05	55.03±5.04	54.97±4.94	54.79±4.90	0.833	0.842	0.322
Mean change Group-A		0.07±0.07	0.06±0.05	2.49±0.05	0.943	0.893	**0.004**
Mean change Group-B		0.31±0.01	0.33±0.1	0.2.51±0.34	0.965	0.883	0.842

[Table/Fig-6]: Echocardiography (ECHO) variables on follow-up.
p-values were calculated using a t-test. Mean change in Groups A and B was calculated between the preoperative period and one month/03 months/06 months

in patients who did not receive PLP [27]. Venkatavijay K et al., found that LV and Ejection Fraction (EF) characteristics did not change significantly before and after surgery [26].

The mitral valve is a complex but well-coordinated anatomical structure necessary for the efficient function of the LV. The mitral valve consists of valve leaflets, annulus, chordae tendineae, papillary muscles, part of the left atrial wall, part of the left ventricular wall, and an adjacent annulus of the aorta. The mitral valve and sub-valvular apparatus can cause the annulus to migrate toward the apex and the LV to concentrically contract during systole, thereby improving left ventricular ejection capacity [28,29].

The authors, through their experience, have observed that shaving of the leaflets is a very important step in the preservation of the posterior leaflets because it determines the division of the leaflets into several segments corresponding to the attached chordae and papillary muscles. The division of the leaflets should be done when the posterior annulus is visible so that the suture insertion is at the correct depth. Complete removal of the valve is preferred if the posterior annulus is calcified.

Limitation(s)

This was a prospective interventional study in which multivariate analysis was not performed; therefore, there is a certain selection bias.

CONCLUSION(S)

The preservation of the posterior leaflet in rheumatic stenosis cases has no improved effect on left ventricular performance. The left ventricular performance does not change even after the six-month follow-up. However, further prospective, randomised, large-scale, long-term studies with multivariate analysis are needed to validate the present results. There is clearly a need for further research comparing preservation techniques for bi-leaflets (MVR-BL) and posterior leaflets (MVR-PL). Additional areas of interest include assessing right ventricular and tricuspid valve function after MVR with dual or PLP versus no valve preservation. Further work also needed to investigate the different sub-groups of patients with mitral regurgitation due to different causes (ischaemic disease, re-operation, or degenerative disease).

Authors' contribution: NKS, AA, and DKS contributed to drafting the manuscript, and NKS and SSR revised it critically for important intellectual content before it was submitted. The final version was reviewed and contributed by all the authors.

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