



Total versus partial chordal preservation in mitral valve replacement: Early results

Authors

**Dr Sunil Dhar MC.h CTVS, Dr Sistla. V.P.L. Chandra Kumar MC.h CTVS,
Dr Madhur Kumar MC.h, Dr Anubhav Gupta-H.O.D.CTVS, Dr Ajit Kumar Padhy***

Department of Cardiothoracic and Vascular Surgery, VMMC and Safdarjung Hospital, Delhi, India

*Corresponding Author

Dr Ajit Kumar Padhy

Department of Cardiothoracic and Vascular Surgery, VMMC and Safdarjung Hospital, Delhi, India

Introduction

The annulo-papillary continuity in mitral valve withstands the hydrostatic force during systole as the chords relay the engendered forces between the leaflets and ventricular wall via contracted papillary muscles. It maintains the structural integrity of tensioned ventricular mass, disruption of which results in deterioration of left ventricular functions in patients undergoing mitral valve replacement.

It has been widely emphasised by authors that the post operative functional outcomes are better with chordal preservation techniques. It is seldom performed in institutions routinely during mitral valve surgery due to the technical complexities involving longer operating time, severe subvalvular calcifications, left ventricular outflow tract obstruction (LVOTO).¹⁻⁵. Patients with septal hypertrophy undergoing anterior leaflet preservation may develop LVOTO as preserved tissue interferes with prosthetic valve functions⁶.

In the similar line, we have studied the varied early outcomes of chordal preservation strategy during mitral valve replacement.

Methods

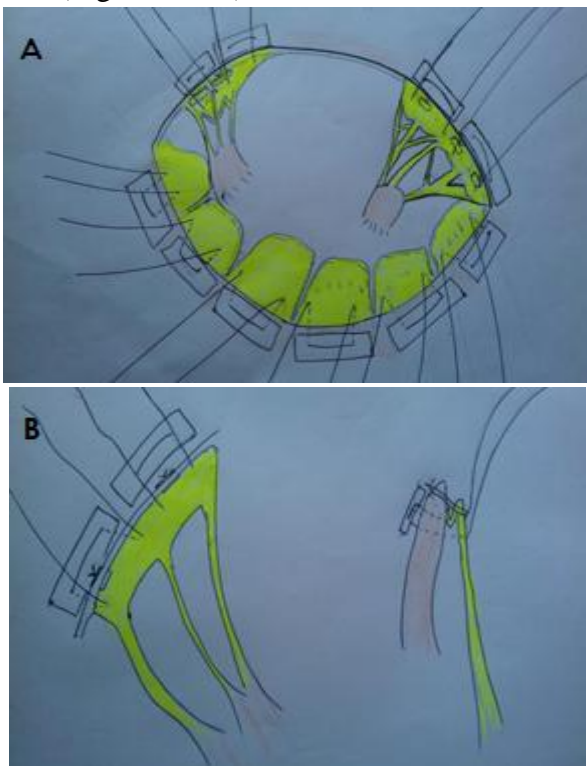
This is a retrospective study of 168 patients who underwent mitral valve replacement (MVR) for both chronic rheumatic mitral stenotic and regurgitant lesions at our institution from January 2016 to January 2018. Data obtained from patient files and outpatient follow-up were evaluated. The patients were divided into 3 groups: Group A (n=37) where total excision of leaflets done with no chordal preservation. Group B (n=87) where posterior leaflet along with its subvalvular structures preserved and Group C (n=44) where total chordal preservation done with partial excision of anterior leaflet.

Excluded from the study were patients undergoing coronary bypass concurrent with MVR, reoperation for MVR, simultaneous aortic valve or aortic surgery, or surgical incision other than sternotomy. All patients having had given informed consent for operation and for use of their medical records for research purposes. All patients received a mechanical bileaflet valve. It was ensured that the preserved chordae tendinae were not interfering with the prosthesis function by

checking disc movement. The technique for preservation of the chordo-papillary apparatus was decided after intraoperative visual inspection of the mitral valve.

Techniques of Chordal Preservation

Total Chordal Preservation: The anterior leaflet was mainly by the modified Miki's technique⁷ The anterior leaflet is partially excised, a flap is cut from the central portion of anterior leaflet anchored to the anterior mitral annulus with polyester sutures. Teflon pledgeted sutures separately used to anchor the prosthesis with remnant of anterior (mural) leaflet and posterior leaflet (Fig. A and B)



(Figure A,B: Mural leaflet is attached with anterior mitral annulus, close to the commissures with braided 2-0 polyester sutures followed by Teflon pledgeted sutures (Atrium to ventricle to leaflet to sewing ring) to minimize any tissue interference of prosthetic valve leaflets)

Partial Chordal Preservation: It involved excision of whole of the anterior leaflet and chordae tendinae with preservation of the posterior leaflet and associated subvalvular apparatus. The posterior leaflet was shaved off excess tissue or imbricated to the annulus using

the same polyester sutures used for implantation of the prosthetic valve after incising the leaflet from edge to base at two or three points in between the scallops.

No Chordal Preservation/ Total excision: was done in severely calcified mitral valves with severe subvalvular calcification and fusion. It involved excision of whole of the mitral valve including the leaflets and subvalvular apparatus. For follow up of these patients, Transthoracic echocardiography was done at the time of discharge and during subsequent follow ups. The functional class was also assessed at follow-up. All patients received oral anticoagulation to maintain an international normalized ratio (INR) between 2.5 and 3.5.⁸

Transthoracic two-dimensional (2D), colour flow and Doppler echocardiography was performed using the PHILIPS machine with 2.5–3.7 MHz transducer. Prosthetic valve function was assessed on 2D and Doppler with multiple views. Echocardiographic data were measured according to the criteria of the American Society of Echocardiography.⁹ Echocardiography variables were noted and compared with preoperative echo reports.

Statistical Analysis

Statistical analysis was performed by the SPSS program for Windows, version 17.0. Continuous variables are presented as mean \pm SD, and categorical variables are presented as absolute numbers and percentage. Data were checked for normality before statistical analysis using Shaipro Wilk test. Normally distributed continuous variables were compared using ANOVA. If the F value was significant and variance was homogeneous, Tukey multiple comparison test was used to assess the differences between the individual groups; otherwise, Tamhane's T2 test was used. Categorical variables were analyzed using the chi square test. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

Results

Demography of the patients has been mentioned in Table 1(a), 1(b) no statistically significant differences observed among the groups. Group

A= No chordal preservation/Total excision, Group B=Partial chordal preservation group, Group-C= Total chordal preservation group

Table 1(a)

	Chordal Preservation			p value
	No (Group-A)	Post (Group-B)	Total (Group-C)	
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (Yrs)	36.97 ± 14.28	35.47 ± 13.15	33.27 ± 10.37	0.417
Weight (Kg)	46.57 ± 10.58	48.69 ± 13.46	47.45 ± 12.39	0.667
Height (cm)	153.03 ± 10.87	153.61 ± 10.04	152.84 ± 11.07	0.911

Table 1(b)

Sex	Chordal Preservation			p value
	No (Group-A)	Post (Group-B)	Total (Group-C)	
	Frequency (%)	Frequency (%)	Frequency (%)	
Female	17 (45.9%)	48 (55.2%)	28 (63.6%)	0.280
Male	20 (54.1%)	39 (44.8%)	16 (36.4%)	
Total	37 (100%)	87 (100%)	44 (100%)	

Patient admitted with severe MS also had MR++. Those patients having severe sub valvular calcifications underwent MVR with no chordal

preservation or posterior chordal preservation depending upon intraoperative findings.

Table 2

Diagnosis	Chordal Preservation			p value
	No	Post	Total	
	Frequency (%)	Frequency (%)	Frequency (%)	
Predominantly MS	34 (91.1%)	66 (75.9%)	30 (68.2%)	0.035
Predominantly MR	3 (8.1%)	21 (24.1%)	14 (31.8%)	
Total	37 (100%)	87 (100%)	44 (100%)	

History of previous interventions not significantly related as shown in Table 3.

Table 3

Previous Intervention	Chordal Preservation			p value
	No	Post	Total	
	Frequency (%)	Frequency (%)	Frequency (%)	
None	34 (91.9%)	77 (88.5%)	40 (90.9%)	0.339
CMV	2 (5.4%)	8 (9.2%)	1 (2.3%)	
CMV+BMV	1 (2.7%)	0 (0.0%)	0 (0.0%)	
PTMC/BMV	0 (0.0%)	2 (2.3%)	3 (6.8%)	
Total	37 (100%)	87 (100%)	44 (100%)	

BMV=Ballon Mitral Valvotomy, CMV= Closed Mitral Valvotomy, PTMC= Percutinous transvenous mitral commissurotomy

Table 4 (a)

Effect on LV dimensions: Table 4(a) and 4(b)

LVES(mm)	Chordal Preservation			p value	No V/S Posterior	No V/S Total	Posterior V/S Total
	No (Group-A)	Posterior (Group-B)	Total (Group-C)				
	Mean ± SD	Mean ± SD	Mean ± SD				
Preoperative	36.97 ± 8.97	39.91 ± 9.42	37.52 ± 9.38	0.183	0.283	0.991	0.435
At 6 months	34.54 ± 8.01	35.95 ± 8.96	33.34 ± 8.69	0.255	0.771	0.890	0.298
Change	2.43 ± 1.77	3.95 ± 1.20	4.18 ± 1.48	<0.001	<0.001	<0.001	<0.001
At discharge	45.46 ± 9.22	46.22 ± 10.41	42.86 ± 10.18	0.199	0.428	1.000	0.425
Change	1.30 ± 1.18	1.95 ± 1.28	1.82 ± 1.53	0.043	0.021	0.240	0.943

LVES: Left ventricular end systolic diameter

Table 4(b)

LV ED(mm)	Chordal Preservation			p value	No V/S Posterior	No V/S Total	Posterior V/S Total
	No (Group-A)	Posterior (Group-B)	Total (Group-C)				
	Mean \pm SD	Mean \pm SD	Mean \pm SD				
Preop	48.89 \pm 9.66	52.84 \pm 10.92	50.3 \pm 10.88	0.132	0.140	0.903	0.507
At 6 months	45.46 \pm 9.22	46.22 \pm 10.41	42.86 \pm 10.18	0.199	0.970	0.548	0.223
At discharge	48 \pm 9.41	49.86 \pm 10.55	47 \pm 10.62	0.294	0.705	0.959	0.381
Change at 6 months	3.43 \pm 1.79	6.62 \pm 1.63	7.43 \pm 1.77	<0.001	<0.001	<0.001	0.038
Change at discharge	0.89 \pm 1.07	2.98 \pm 1.15	3.3 \pm 0.98	<0.001	<0.001	<0.001	0.273

LVED: Left ventricular end diastolic diameter

There is a non significant dilation of Left ventricular end systolic dimension in all groups at the time of discharge, however at 6 months follow up there is a reduction systolic dimension noted in all groups and the effect is maximum in Group C when compared with Group A and B ($p < 0.001$). All groups showed significant reduction in end diastolic dimensions at the time of discharge and

at 6 months follow up. Though the pre operative end diastolic dimensions are more in Group-B but the dimensional reduction is noted most and statistically significant in Group-C. The reduction in diastolic diameter in Group C is not statistically significant when compared with Group B at the time of discharge ($p = 0.0273$) and at 6 month follow up ($p = 0.038$).

Effect on Left ventricular ejection fraction (LVEF): Table 5

Table 5

LVEF(%)	Chordal Preservation			p value	No V/S Posterior	No V/S Total	Posterior V/S Total
	No (Group-A)	Posterior (Group-B)	Total (Group-C)				
	Mean \pm SD	Mean \pm SD	Mean \pm SD				
Preop	57.35 \pm 4.06	58.00 \pm 3.30	57.91 \pm 4.02	0.659	0.778	0.901	0.999
At 6 months	54.49 \pm 4.83	55.47 \pm 4.33	55.3 \pm 4.39	0.525	0.639	0.819	0.996
At discharge	52.57 \pm 7.05	52.23 \pm 5.75	51.32 \pm 5.08	0.595	0.992	0.752	0.732
Change at 6 months	2.86 \pm 3.99	2.53 \pm 3.69	2.56 \pm 3.91	0.899	0.961	0.980	1.000
Change at discharge	4.78 \pm 5.40	5.77 \pm 5.24	6.59 \pm 4.63	0.289	0.727	0.304	0.74

LVEF: Left ventricular ejection fraction

There is a non significant reduction in LVEF seen in all the groups at the time discharge and all the groups showed improvement in ejection fraction

at 6 months follow up which is statistically non significant.

Effect on Left atrial (LA) Size: Table 6

Table 6

LAES(mm)	Chordal Preservation			p value	No V/S Posterior	No V/S Total	Posterior V/S Total
	No	Posterior	Total				
	Mean \pm SD	Mean \pm SD	Mean \pm SD				
preoplaes	51.73 \pm 16.82	45.93 \pm 14.95	53.15 \pm 19.09	0.036	0.208	0.978	0.092
post op laes	49.24 \pm 13.88	43.08 \pm 12.54	46.98 \pm 12.7	0.037	0.068	0.833	0.270
Change	2.48 \pm 6.70	2.6 \pm 8.12	3.18 \pm 18.10	0.199	1.000	0.515	0.521

LAES: Left atrial end systolic diameter

There is a non significant reduction in LA size noted in all the groups.

Effect on Atrial fibrillation: Table 7

Table 7

RHYTHM	No		p value	Post		p value	Total		p value
	Pre	Post		Pre	Post		Pre	Post	
AF (Rate-80-120bpm)	7 (18.9%)	4 (10.8%)	0.515	15 (17.2%)	11 (12.6%)	0.524	8 (18.2%)	3 (6.8%)	0.196
AF/CVR (Rate<80bpm)	3 (8.1%)	5 (13.5%)	0.711	10 (11.5%)	12 (13.8%)	0.691	5 (11.4%)	5 (11.4%)	1.000
AF/FVR (Rate:120-160bpm)	2 (5.4%)	-	0.493	11 (12.6%)	-	<0.001	13 (29.5%)	-	<0.001
NSR	25 (67.6%)	28 (75.7%)	0.607	51 (58.6%)	64 (73.6%)	0.037	18 (40.9%)	36 (81.8%)	<0.001
Total	37 (100%)	37 (100%)		87 (100%)	87 (100%)		44 (100%)	44 (100%)	

AF:atrial fibrillation (ventricular rate 81-120 beats per minute) ,CVR:controlled ventricular rate(<80 beats per minute), FVR: fastventriculae rate(120-160 beats per minute), NSR: normal sinus rhythm

Conversion to Normal sinus rhythm in immediate post operative period is statistically significant in Group C (p<0.001) where as not significant in Group B (p=0.0273) and A(p=0.038).

There is a significant increase in cross clamp time and cardio pulmonary bypass time noted in Group-C (p<0.001). Group-C also received a

bigger size prosthesis though statistically not significant.

Except for one patient in group-B had a post operative stroke there is no other major adverse cardiovascular event noted in all the groups. No prosthetic valve dysfunction and operative mortality observed in all the groups.

Effect on NYHA Function: Table 8 (a) & 8 (b)

Table 8 (a)

NYHA (Pre-operative)	Chordal Preservation			p value
	No	Post	Total	
	Frequency (%)	Frequency (%)	Frequency (%)	
II	36 (97.3%)	79 (90.8%)	39 (88.6%)	0.661
III	1 (2.7%)	7 (8.0%)	4 (9.1%)	
IIII	0 (0.0%)	1 (1.1%)	1 (2.3%)	
Total	37 (100%)	87 (100%)	44 (100%)	

Table 8 (b)

NYHA (Post-operative)	I	II	III	IV	Total
No	Pre		36 (97.3%)	1 (2.7%)	37 (100%)
	Post	30 (81.1%)	7 (18.9%)		37 (100%)
p value	<0.001	<0.001	1.000		
Post	Pre		79 (90.8%)	7 (8.0%)	87 (100%)
	Post	59 (67.8%)	28 (32.2%)		87 (100%)
p value	<0.001	<0.001	<0.001	1.000	
Total	Pre		39 (88.6%)	4 (9.1%)	44 (100%)
	Post	34 (77.3%)	10 (22.7%)		44 (100%)
p value	<0.001	<0.001	0.116	1.000	

There has been overall decrease in symptoms in all the three groups with maximum improvement in symptoms Total Chordal Preservation group as per NYHA grading.

Discussion

Wiggers and Katz¹⁰ first proposed the concept of annulo papillary continuity and later on by Rushmer *et al*¹¹. As per this concept, there is a dynamic interaction between the mitral annulus and left ventricular wall which is responsible for

the LV function and geometry. The first MVR was reported in 1961 using (Starr-Edwards prosthetic valve) and it involved complete excision of mitral leaflets, chordae tendineae and tips of the papillary muscles.¹² Initially, there was an increased incidence of low cardiac output syndrome and associated mortality. Despite satisfactorily functioning prosthetic valves, approximately 50% of patients were dying from heart failure within 5 years. Post mortem examination revealed a globular remodeling of the ventricular cavity. In 1964, Lillehei tried to reduce postoperative low cardiac output syndrome by adapting to the concept of chordal preservation¹³ and subsequently reported a reduction in operative mortality from 37% to 14%.^{14,15}

Rastelli experimented on animal models and concluded that after mitral valve replacement with Starr-Edwards prosthesis, the cardiac performance was unaffected irrespective of whether the chordae were preserved or resected.¹⁶

In a randomized trial, David in 1994, showed that chordal preservation resulted in better LV function than those with no preservation, even after 7 years.¹⁷

Hansen et al demonstrated LV function was more affected when the chordae to the AML were excised as compared to those of the PML¹⁸ and chordal preservation is superior to conventional MVR in terms of exercise capacity, LV systolic dimensions and ejection fraction was shown by Rozich¹⁹ and colleagues and Hannin³ and colleagues. Hansen observed best LV function with preservation. of the entire subvalvular apparatus, reasonable with preservation of either the AML or PML and poorest with transection of all chordae. Our study revealed improved functional outcome, improvement of LV function and better remodeling of LV diameters with total chordal preservation group corroborating with the other studies^{18,19,21,22}. The functional outcome in our patients in addition to the above mentioned factors also attributed to the reduction of size of left atrium and restoration of normal sinus rhythm in immediate post operative period.

Microsimulation study done by Christopher Rao et al., revealed longer survivality and better quality of life with complete preservation of sub valvular apparatus.²⁰

Chowdhury et al, concluded that chordal preservation either posterior or total results in significant improvement in LV function immediately or late postoperatively. The total chordal preservation group did demonstrate greater fractional change of LV end systolic volume as compared to posterior chordal preservation and nonchordal group.^{21,22}

Conclusion

The technical complexity in total chordal preservation do not undermine the beneficial effects of better left ventricular remodelling, preservation of heart function and functional outcome in patients undergoing mitral valve replacement.

Study Limitations

This is a retrospective study ,hence we did not emphasise on the stenotic or regurgitant lesions separately as these did not influence in picking up total, less or no chordal preservation strategies, which otherwise could have pronounced a significance in left ventricular function. At the time of surgery operating surgeon was the deciding factor for choice of procedure of chordal resection, posterior mitral valve preservation or total chordal preservation .Patient factors which influenced the strategy are severe subvalvular calcification and size of mitral valve annulus . Follow up of patients was restricted to six months because of remote access, poor transportation and low socioeconomic status. Multiple echocardiographers and echo machines were used during study. However, all the echocardiographers were certified cardiologists from the same department.

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