Mitral Valve Repair – Single Centre experience with 5 year follow up study of operated patients

Thesis Submitted By

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In Partial Fulfillment of the Requirement for the Degree Of

MCh in Cardio Vascular and Thoracic Surgery

2018-2020

Under the guidance of

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DECLARATION

I, **Dr. Sai Suraj Kotera**, hereby declare that this thesis titled *"***Mitral Valve Repair – Single Centre experience with 5 year follow up study of operated patients***"* has been prepared by me under the capable supervision and guidance of

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CERTIFICATE

We hereby certify that this thesis titled

*"***Mitral Valve Repair – Single Centre experience with 5 year follow up study of operated patients***"* is the bonafide work of **Dr. Sai Suraj Kotera**, MCh CVTS resident, done under our guidance at Department of cardiovascular and thoracic surgery at Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram.

He has shown keen interest in preparing this project.

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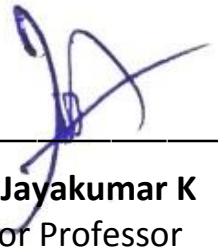

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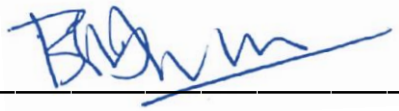

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Institutional Ethics Committee
(IEC Regn No. ECR/189/Inst/KL/2013/RR-16)

SCT/IEC/1232/AUGUST-2018

07.09.2018

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Dear Dr.Sai Suraj Kotera,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "MITRAL VALVE REPAIR – SINGLE CENTRE EXPERIENCE WITH 5 YEAR FOLLOW UP STUDY OF OPERATED PATIENTS (IEC/1232)" on 17th August, 2018.

The following documents were reviewed:

Original submission

1. *Covering letter addressed to the Chairman, IEC, SCTIMST with checklist*
2. *TAC Approval Letter*
3. *IEC Application Form*
4. *Project Proposal*
5. *Forwarding Letter from the HOD*
6. *Proforma*
7. *Declaration Form*
8. *CV of Principal Investigator and Co- Principal Investigators*

Revised submission

1. *Covering letter addressed to the Member Secretary, IEC, SCTIMST with checklist*
2. *TAC Approval Letter*
3. *IEC Application Form*
4. *Project Proposal*
5. *Forwarding Letter from the HOD*
6. *Proforma*
7. *Declaration Form*
8. *CV of Principal Investigator and Co- Principal Investigators*

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The following members of the Ethics Committee were present at the meeting held on 17th August, 2018 at G. Parthasarathi Board Room, AMCHSS, SCTIMST

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. R V G Menon	M Tech, PhD	Male	Lay Person (Chairman)	No
2.	Dr. V. Raman Kutty	M D, M Phil, M P H	Male	Health Sciences Expert/Clinician	Yes
3.	Dr. K R S Krishnan	M.E., Ph.D.	Male	Medical Technology	Yes
4.	Dr. Rema M. N	MD	Female	Basic Medical Scientist	No
5.	Dr. Mala Ramanathan	PhD	Female	Social Scientist (Member Secretary)	Yes

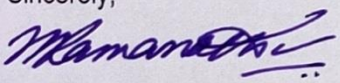
IEC Decision

The IEC approved the conduct of the study in the present form.

Remarks:
The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,



Mala Ramanathan
Member Secretary, IEC

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An ostentatious use of words will not be sufficient to express my heartiest thanks to my guide **Dr. Varghese T Panicker**, Additional Professor, Department of Cardiovascular and Thoracic Surgery, SCTIMST, Thiruvananthapuram. His valuable and critical suggestions, constant inspiration and encouragement, instinctive corrective measures, timeless efforts, unstinted cooperation and mental support throughout have made this marathon task a smooth journey.

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Sometimes it is not easy to express in words especially when you have to say thanks to your parents for their constant undemanding love, dedication, sacrifice, inspiring guidance, affectionate encouragement and ever ending enthusiasm, without which this study would not have seen the light of the day. Thanks to my dad **Dr. K.S Somashekar**, mom **Mrs. Sudhashekar**, grandparents and parents in law. Thanks to my wife **Dr. Samskruthi S** for her unconditional support and love throughout without which it would been difficult.

Last, but not the least, I thank the **almighty God** for being the silent force behind everything.

Dr. Sai Suraj Kotera

Senior Resident

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LIST OF ABBREVIATIONS

MV – Mitral Valve

MR – Mitral Regurgitation

LV – Left Ventricle

NYHA – New York Heart Association

FC – Functional Class

BSA – Body surface area

LVEF – Left ventricular Ejection fraction

LVEDD – Left ventricular End diastolic diameter

LVESD – Left ventricular End systolic diameter

IMR – Ischemic Mitral Regurgitation

FMR – Functional Mitral Regurgitation

MVR – Mitral Valve Replacement

TEE – Trans Esophageal Echocardiography

PISA – Proximal isovelocity surface area

SAM – Systolic anterior motion

PTFE – Polytetrafluroethylene

EOAI – Effective orifice area index

ASD – Atrial Septal Defect

SD – Standard Deviation

AF – Atrial Fibrillation

CVA – Cerebrovascular Accident

INR – International Normalized Ratio

ABSTRACT

Background

In this current era, Mitral Valve (MV) repair is the operation of choice for Mitral insufficiency due to myxomatous degenerative pathology of Mitral Valve. MV repair for insufficiency was first done as early as in 1957 by Dr. C. Walton Lillehi at University of Minnesota. In next few years, Modern techniques for MV repair was brought into light by Dr. Dwight C. McGoon of the Mayo Clinic in 1960. A technique to repair a ruptured cord in the posterior leaflet of the mitral valve was described. In 1983, Dr. Alan F.Carpentier presented a game changing paper "The French Correction". His paper gave the basic pathophysiological classification of mitral valve lesions and essentially a pre-operative plan for how to successfully and reproducibly repair mitral valve insufficiency, particularly from degenerative myxomatous MV disease.

Key principles for repair of the myxomatous mitral valve is to address anatomical problem first. Once this is done, one should resist the temptation to do more than one needs "less is more".

With constant advancement in surgical expertise and numerous techniques along with usage of newer profile prosthetic rings more and more patients are subjected to mitral valve repair. This study was designed with an aim to appraise the outcome of Mitral valve repair during immediate post-operative period and on follow up of patients. Other objectives of study was to evaluate the number of Re interventions done following MV Repair, Quality of life / Functional class of patient post mitral valve repair, To compare outcome between Rigid and flexible prosthetic rings used for MV repair. Prospective follow up of patients who have undergone MV Repair was done to evaluate the result of MV Repair.

Study design & Methods

This is Retrospective Observational study with Prospective follow up of patients. Data of patients who have undergone Mitral valve repair in SCTIMST from 01/01/2012 to 31/12/2016 was collected from medical records. Which included pre-operative, Intra operative and post-

operative follow up records of patient from OPD. Patient was followed up in OPD during their regularly yearly follow up. Total of 173 patients underwent Mitral valve repair during 2012 – 2016. Among the 173 patients 127 patients underwent Mitral Valve repair alone for Degenerative Mitral Valve disease. 8 patients for Ischemic Mitral regurgitation. 29 patients had intervention on other valves along with Mitral Valve repair. 9 patients underwent Mitral valve repair for Congenital / along with Ostium primum ASD Closure. 127 patients fulfilled Inclusion and Exclusion criteria of our study and were considered for follow up. Among them were 78 males and 49 females. 12 patients were lost for follow up during median follow up of 5 years.

Results

Pre-operative patient Characteristics revealed mean age of operated patients was 38.3 years and with mean BSA of 1.68 m^2. 62.2 % of patients were in NYHA Functional class II pre operatively. 81.88 % had severe MR IV + and were symptomatic before surgery. 12.5 % already had atrial fibrillation. 51.28 % of patients had Mild PAH, who were most in study population. Most of MV repair was done for Posterior leaflet prolapse which was for 49.6 % of patients, followed by 19.6 % of patients for bileaflet repair. 36.2% of patients had associated Mild – Mod tricuspid regurgitation during pre-operative evaluation. Operated patients had a mean of 49 % LVEF pre MV Repair. Mean LVEDD was 60.57 mm and Mean LVESD was 35.93 mm among operated patients.

All patients underwent MV repair with Prosthetic ring annuloplasty. Triangular resection was the most preferred technique for posterior leaflet repair in 46.31 % of patients who underwent posterior leaflet repair. For anterior leaflet repair Neochordal reconstruction was the most preferred technique in 93.7% of patients who underwent anterior leaflet repair.

Post operatively 77.3 % of patients were in NYHA Functional class I at the end of median follow up of 5 years. 90.4 % of patients showed no evidence of PAH during follow up. 92.1 % of patients had Trivial – Mild MR during follow up period after 5 years of surgery. 2 patients underwent Redo MVR during immediate post op period due to persistence of Severe MR IV + post MV repair. Mean LVEF improved to 53 % in patients post MV repair and was preserved during follow up. Freedom from Re operation is at 98.45% in our study. No patient had infective

endocarditis and 1 patient suffered from CVA, who was receiving Anti coagulation for atrial fibrillation during follow up.

62.2 % of patients underwent annuloplasty with flexible prosthetic ring and SJM Taylor prosthetic ring was the preferred ring in 38.5 %, followed by Duran anncore prosthetic ring in 23.6 % of patients. 37.7 % of patient's annuloplasty was done with rigid prosthetic ring and Physio II prosthetic ring was the most preferred ring in 18.1 % of patients. Analysis of pre-operative Left Ventricular dimensions to post-operative regressed Left Ventricular dimensions were comparable in Rigid and flexible prosthetic ring groups with good current functional class of operated patients in both groups.

Conclusion

By this current study with a 5 year follow up, which has good long term results in aspect of Freedom from progression of Mitral regurgitation, Freedom from Re operation or complications. Mitral Valve repair is a procedure which gives long standing remedy for mitral regurgitation, if we follow the basic principles of durability of repair regardless of the type of annuloplasty. Burden of long term Anti coagulation is relieved in patients who underwent MV repair and with good regressed LV dimension in both prosthetic ring groups, We recommend MV repair for all degenerative mitral valve disease and consideration of BSA during sizing of ring to prevent postoperative functional mitral stenosis or residual insufficiency rather than type of ring.

Keywords: Mitral Valve regurgitation, Degenerative mitral valve disease, Mitral Valve repair, Flexible and Rigid Prosthetic rings.

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INTRODUCTION

Degenerative, ischemic, rheumatic and infectious (endocarditis) processes are responsible for mitral valve disease in adults. Mitral valve repair of native valve has been widely preferred as optimal surgical procedure to treat mitral valve dysfunction of all etiologies [1]. It is currently most commonly performed surgical procedure for mitral valve regurgitation. This requires special expertise, but the advantages for the patient are significant and include improved life expectancy, avoidance of long-term anticoagulation, and better preservation of native heart function.

The first successful valve surgery of any kind occurred at Peter Bent Brigham Hospital in 1923. Dr. Elliot C. Cutler, performed the first successful mitral valve repair [2]. The patient was a young girl with rheumatic mitral valve stenosis who was comatose from low cardiac output. Cutler pushed a knife through the apex of left ventricle, then encountered mitral orifice and performed a blind mitral commissurotomy.

The first mitral valve repair for mitral insufficiency was performed by Dr. C. Walton Lillehei at the University of Minnesota in 1957 [3,4]. Subsequently, the forerunner of the modern techniques for mitral valve repair was reported by Dr. Dwight C. McGoon of the Mayo Clinic in the *Journal of Thoracic and Cardiovascular Surgery* in 1960 [5]. A technique to repair a ruptured cord in the posterior leaflet of the mitral valve was described. Dr. Miller and colleagues at Stanford University then demonstrated the importance of the mitral apparatus in maintaining good ventricular function after mitral valve surgery. This means that the chordae and the papillary muscles should remain intact, which is obviously best achieved by mitral valve repair [6,7,8].

In the 1980s, there was an increased incidence of mitral valve repair, primarily as a result of improved myocardial protection, the recognition that papillary muscle integrity is critical to maintain good ventricular function and long term data with reconstructive techniques showing excellent outcomes. In contrast, late results with bioprosthetic and prosthetic valves were good but still had a lot of problems. Long term data showed that these valves degenerated in time and that mitral valves needed to be repaired whenever possible.

In 1983, Dr. Alain F. Carpentier of the University of Paris published a seminal paper called "The French Correction" in the *Journal of Thoracic and Cardiovascular Surgery* [9]. This paper outlined the basic pathophysiological classification of mitral valve lesions and provided the tools and essentially a game plan for how to successfully and reproducibly repair mitral valve regurgitation, particularly from degenerative myxomatous mitral valve disease. Many surgeons throughout the world were inspired by this paper to perform mitral valve repair operations. The increasing success rate of mitral valve repair subsequently resulted in earlier referral of patients with mitral valve disease for surgical repair.

One of the key principles for repair of the myxomatous mitral valve is that "less is more". The basic anatomic problem should be relieved first. Once this is done, one should resist the temptation to do more than one needs.

With constant advancement in surgical expertise and numerous techniques along with usage of newer profile prosthetic rings more and more patients are subjected to mitral valve repair. There is a need for prospective follow up of patients who have undergone MV Repair and to evaluate the result of MV Repair.

This study was designed with an aim to appraise the outcome of Mitral valve repair during immediate post-operative period and on follow up of patients. Other objectives of study was to evaluate the number of Re interventions done following MV Repair, Quality of life / Functional class of patient post mitral valve repair, To compare outcome between Rigid and flexible prosthetic rings used for MV repair.

STUDY DESIGN & PATIENTS

Study type – Retrospective Observational study with Prospective follow up of patients

Study design – Observational model

Patient data from medical records was collected, which includes pre-operative, Intra operative and post-operative follow up records of patient from OPD. Patient was followed up in OPD during their regularly yearly follow up and data was collected from OPD records.

Aim of study

To appraise the outcome of Mitral valve repair immediately post operatively and on follow up of patients.

Objectives of study

- To assess the outcome of mitral valve repair post 5 years of surgery
- To evaluate the number of Re interventions done following MV Repair.
- To evaluate quality of life of patient / Functional class post mitral valve repair.
- To compare outcome between Rigid and flexible prosthetic rings used for MV repair.

Sampling method – Non Random

Study population – All patients who underwent MV repair in SCTIMST during period of 01/01/2012 to 31/12/2016

Data collection procedure – Hospital Medical records

Eligibility Criteria

Inclusion Criteria – All patients who underwent MV repair for Myxomatous / Degenerative Mitral Valve disease in SCTIMST during period of 01/01/2012 to 31/12/2016

Exclusion Criteria –

- Patients under the age of 18
- Patients who underwent Mitral Valve repair for Ischemic / rheumatic etiology
- Patients who underwent intervention for another valve other than mitral valve repair at the same time

Study groups –

- MV repair with rigid annuloplasty ring and MV repair with Flexible annuloplasty ring

REVIEW OF LITERATURE

Surgical Anatomy of the mitral valve

Mitral valve is situated between the left atrium and left ventricle. Mitral apparatus includes the leaflets, annulus, chordae tendinae, papillary muscles, and left ventricle. It has two leaflets, the anterior (aortic) and posterior (mural) leaflet. Both leaflets are attached directly to the mitral annulus and to the papillary muscles by primary and secondary chordae. Chordae tendinae arise from the papillary muscles and insert into mural surface of leaflets [10].

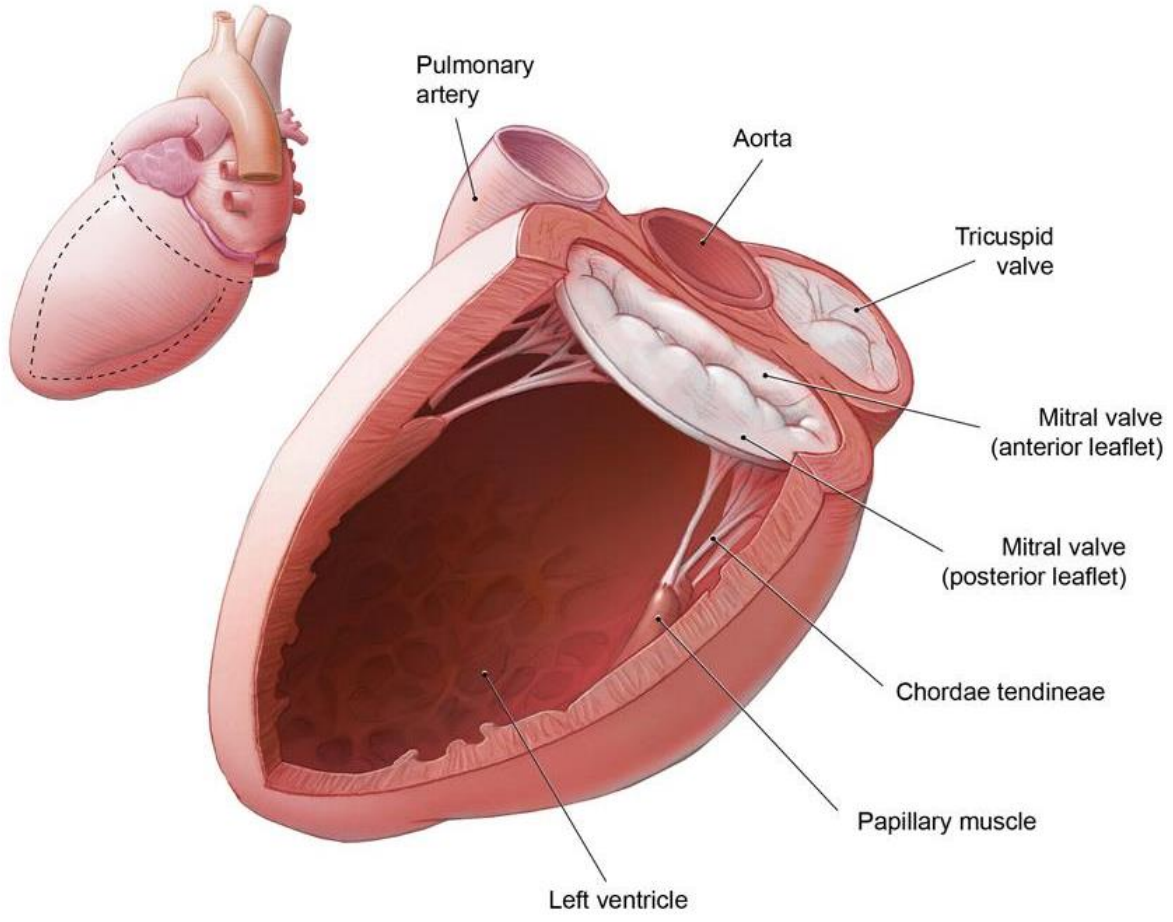


Fig. 1. Components of Mitral apparatus

Anterior mitral leaflet roughly resembles a truncated triangle and is much more mobile than the posterior leaflet [11]. Anterior leaflet is in direct continuity with the fibrous skeleton of the heart. It occupies 35–45% of the annular circumference, but its leaflet area is almost identical to that of the posterior leaflet. Posterior leaflet is rectangular and has three scallops: a middle, a posteromedial and an anterolateral scallop [12]. Two leaflets are connected at the annulus by the posteromedial and anterolateral commisures, which are usually distinctly developed [13]. Motion of the posterior leaflet is more restricted than that of anterior leaflet [14]. Posterior mitral leaflet is attached to thinner chordae tendinae than the anterior leaflet and its motion is restrained by chordae during both systole and diastole [13]. In normal valves, posterior movement of the much more mobile anterior leaflet into apposition with the much less mobile posterior leaflet is responsible for the bulk of the systolic closure of the mitral orifice [10]. This is such as the posterior annulus is more flexible and it is not attached to rigid surrounding structures [14].

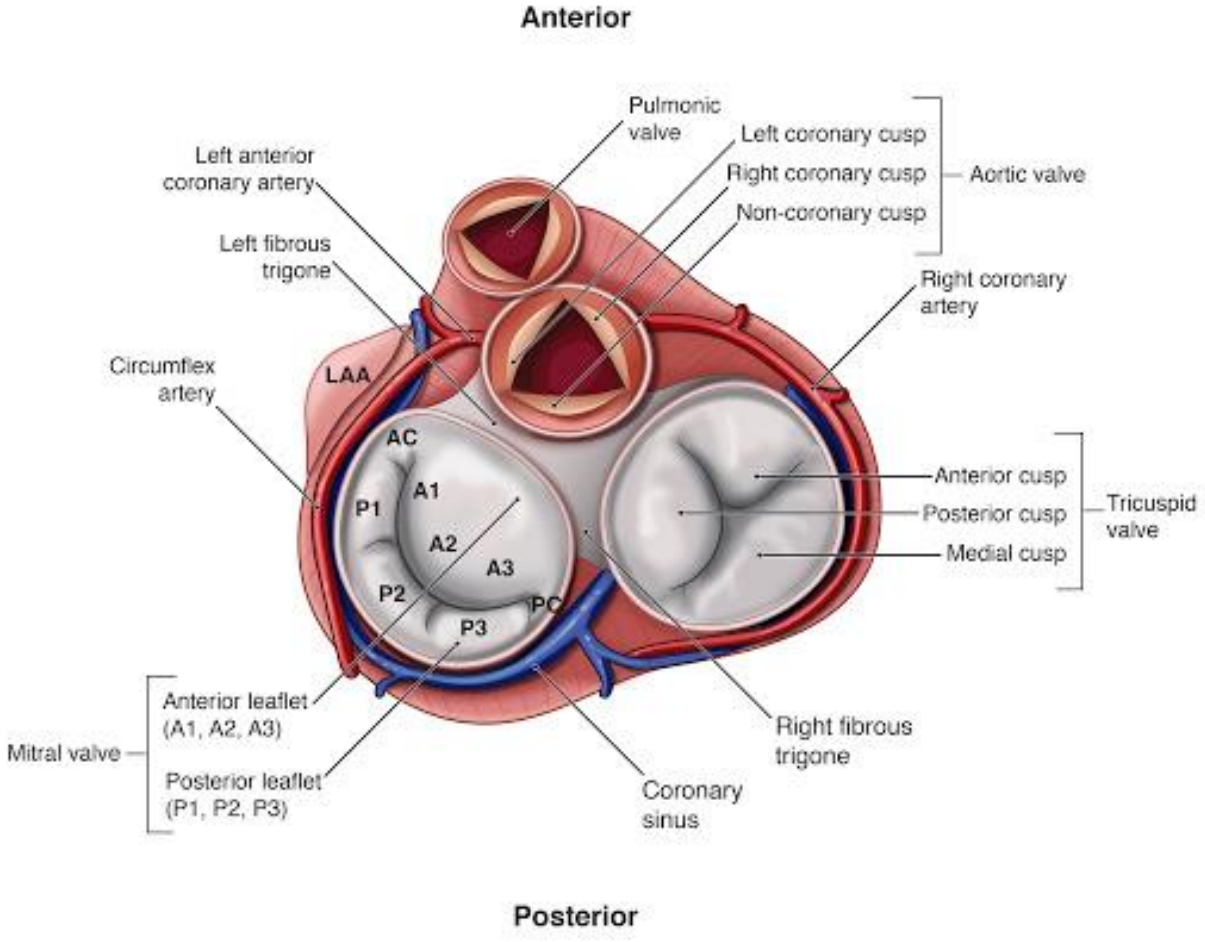


Fig. 2. The relationships of the cardiac valves

Mitral annulus is a pliable junctional zone of fibrous and muscular tissue joining left atrium and ventricle which anchors the hinge portion of the anterior and posterior mitral leaflets [13]. The average area of the mitral orifice as defined by the mitral annulus is 6.5 cm^2 in women and 8 cm^2 in men. The effective orifice area through the level of the leaflets measured clinically is about 30% less than the above mentioned values [10]. The area of the mitral orifice is reduced by 25–40 % during systole, mainly as a result of a dynamic reduction of the size of the posterior annulus which decreases the anteroposterior diameter of the valve orifice and increases the area of leaflet coaptation [15].

Mitral annulus is roughly elliptical, with greater eccentricity in systole than in diastole, while in a three- dimensional model the annulus is described as being "saddle-shaped" [13]. During systole the height of the saddle is increased as the annular dimensions decrease [10]. The mitral annulus moves upward into the left atrium in diastole and toward the LV apex during systole. The annulus moves little during late diastole. The annulus moves a greater distance (3 to 16 mm toward the LV apex) during isovolumic contraction and ventricular ejection. The orifice of the mitral valve changes shape, from elliptical during systole to circular during late diastole. The annulus is flexible and decreases in diameter during each systolic contraction by approximately 26%**.** This flexibility increases leaflet coaptation during systole and maximizes the orifice area during diastole [13].

Circumflex coronary artery courses laterally around the mitral annulus in the posterior atrioventricular groove. The coronary sinus runs more medially in the same groove. Aortic valve is situated between the anterior and posterior fibrous trigones. The bundle of His is located near posterior trigone. The artery feeding atrioventricular node, usually a branch of the right coronary artery, runs a course parallel and is located close to the annulus of the anterior and posterior fibrous trigones [12].

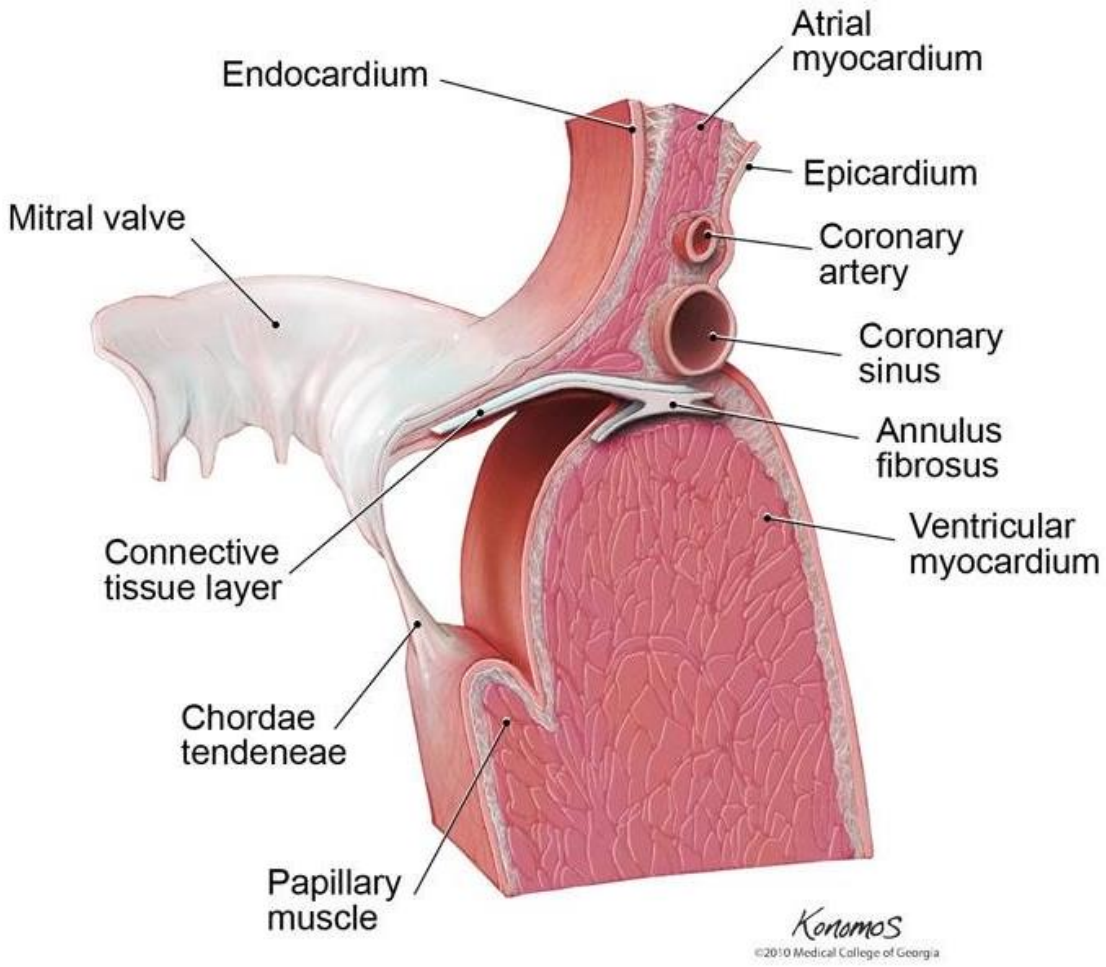


Fig. 3. Surgical anatomy of the mitral valve. Note its important anatomic relationships with the circumflex coronary artery, and the coronary sinus

Chordae tendinae arise from papillary muscles or left ventricular wall and are distributed to both leaflets. The papillary muscles typically consist of two prominent structures: an anterolateral and posteromedial papillary muscle. Papillary morphology may vary widely from this form. Flattened sheets of muscle can give rise to the chordae, and in some cases the chordae appear to arise from the wall of the ventricle itself [(10)]. Anterolateral papillary muscle receives blood from the septal branches of left anterior descending artery, and from the branches of circumflex artery. Posteromedial papillary muscle receives its blood supply from either the left circumflex artery or from a distal branch of right coronary artery, depending on which is the dominant system. It is more prone to ischemia and rupture caused by coronary artery occlusion than the anterior papillary muscle [(15)].

Chordae tendinae are classically and functionally divided into three groups. First-order or primary chordae originate near the papillary muscle tips and insert on the leading edge of the leaflets. These chordae prevent valve edge prolapse during systole. Secondary chordae originate in the same location and insert on the ventricular surface of the leaflets at the junction of the rough and clear zones [13]. These chordae contribute to ventricular function. Secondary chordae enable the ventricle to contract in an efficient cone-shaped fashion. In fact, when the secondary chordae are excised, the left ventricle assumes a globular shape [12]. The tertiary or basal chordae, originate directly from trabeculae carnae of the ventricular wall, and attach to the posterior leaflet near the annulus [13]. Chordae insertions into the posterior leaflet are formed in three layers: marginal attached to the edge, intermediate and mural. Chordae of anterior leaflet insert primarily into free margin of leaflet and there are fewer chordae attached to other portions of the underside of the anterior leaflet [10]. The contribution of the papillary muscles to left ventricle chamber volume is 5% to 8% during diastole, and 15% to 30% during systole [13]. The posterior left ventricular wall and papillary muscles play an important role in leaflet coaptation and valve competence [14]. Papillary muscles help to maintain the optimal position of the subjacent ventricular wall during systole, which in turn preserves the conical shape of the ventricle during systole [10]. Ventricular dilatation may affect the alignment and tension on the papillary muscles and therefore valve competence [12].

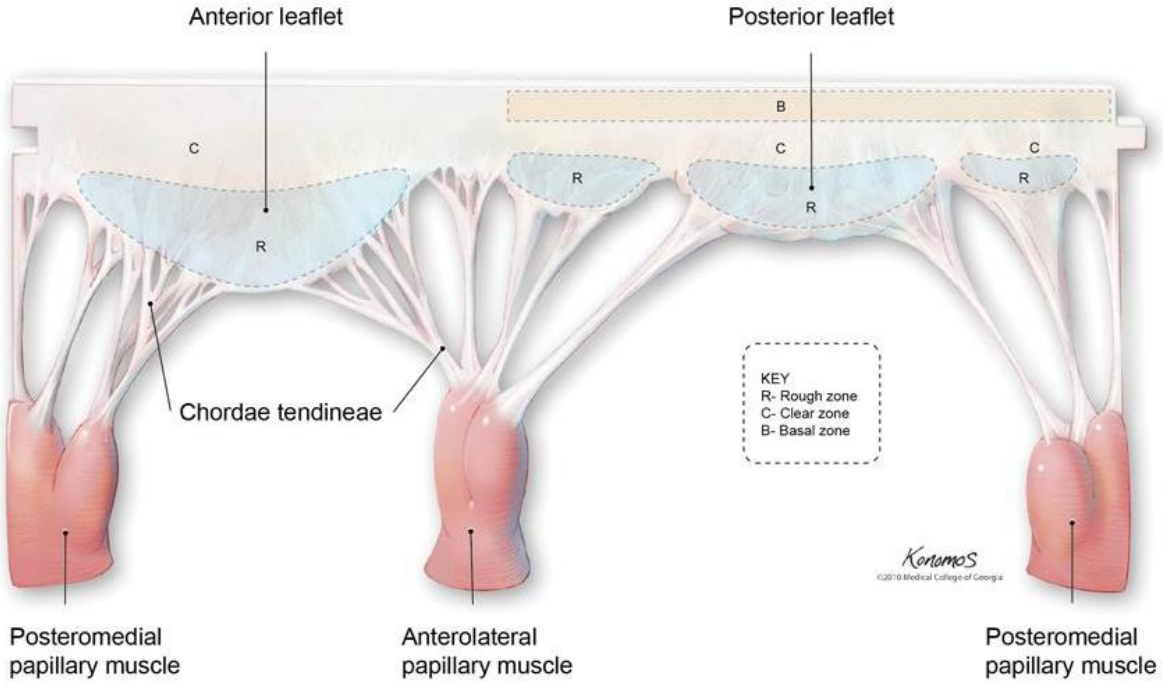


Fig. 4. Anatomy of the mitral valve – Leaflet and Chordae tendinae

Mitral Regurgitation

Mitral regurgitation (MR) is a common valvular disorder which can arise from abnormalities of any part of the mitral valve apparatus. There is an abnormal flow of blood from the left ventricle to the left atrium across an incompetent mitral valve during ventricular systole [16].

The widespread use of colour Doppler echocardiography, a sensitive technique for detecting valvular regurgitation, has increased the recognition of this condition in even healthy subjects. The true prevalence of chronic mitral regurgitation is unknown. A trivial amount of mitral regurgitation is detectable with sensitive Doppler techniques in up to 70% of normal adults. This is often called physiologic mitral regurgitation. In a review of 3486 subjects in the Strong Heart Study, the prevalence of moderate or severe mitral regurgitation was 0.2– 1.9% [17]. In the Framingham study, a population-based cohort, mitral regurgitation of mild severity or worse on colour Doppler echocardiography was present in 19% of men and women [18]. In the Coronary Artery Risk Development in Young Adults study, which consists of 4352 healthy men and women between 23 and 35 years of age, mitral regurgitation was noted as present in 10.9% of the cohort. Of these cases, 93 % were mild in severity [19]. The Cardiovascular Health Study assessed 5201 randomly selected people aged 65 and older with echocardiography. The prevalence of MR was 30.1%, with 26.6% of the cases meeting the criteria for moderate-to-severe regurgitation [20].

Mitral regurgitation burdens the left ventricle with an excessive volume load. This increment in volume produces a preload-dependent increase in LV stiffness, which adds to the pulmonary venous hypertension. LV preload reserve is exploited, and the Frank-Starling mechanism contributes to an increase in the total stroke volume. At the same time, the low-pressure runoff into the left atrium effects a systolic unloading, which also contributes to an increase in stroke volume which leads to a series of compensatory myocardial and circulatory adjustments [21]. These adjustments vary over the prolonged course of the disorder, so that the changes that are operative in acute or subacute MR are eventually replaced by other compensatory mechanisms. Finally, the myocardium fails, the ventricle decompensates, and

the patient exhibits signs of heart failure [22, 23, 24].

Etiology

Dysfunction of one or more components of the valvular-ventricular complex can lead to mitral regurgitation during ventricular systole. Diastolic regurgitation results from delayed ventricular contraction, but this phenomenon appears to have few clinical implications [13].

In the past, rheumatic fever was the predominant cause of mitral regurgitation. Nowadays, the most common etiology of systolic mitral regurgitation in patients undergoing surgery is myxomatous degeneration, also termed flail leaflet, floppy mitral valve or mitral valve prolapse (29–70% of cases) [13]. Other causes include ischemic mitral regurgitation (IMR), dilated cardiomyopathy (also termed functional mitral regurgitation (FMR), mitral annular calcification, infective endocarditis, idiopathic chordal rupture, congenital anomalies, endocardial fibrosis, collagen-vascular disorders and traumatic rupture [13].

Degenerative Mitral Valve Disease

Degenerative mitral valve disease is the second most common form of valvular heart disease in India. The estimated prevalence is 4–5% of the general population. Approximately 5% of the patients with mitral valve prolapse ultimately develop mitral regurgitation requiring surgery [25]. Some degree of mitral valve prolapse is seen in echocardiography in 5% to 6% of the normal female population. It can be familial and associated with hypertension [26]. Although mitral valve prolapse appears to be more widespread in women, severe mitral valve regurgitation due to mitral valve prolapse is more common in men [13]. The classic features of degenerative mitral valve disease include leaflet prolapse (the posterior leaflet more commonly) and annular dilatation [12]. A prolapse is considered to be present when the free edge of one or both leaflets overrides the plane of the valve orifice (annulus) during systole [15]. Chordae may be elongated, thinned, ruptured or thickened [12]. The prognosis for the mitral valve prolapse syndrome is benign. The age-adjusted survival rate of both men and women with mitral valve prolapse syndrome is similar to that of individuals without this common clinical entity [27].

Mitral annular calcification is a degenerative disease that is essentially limited to the elderly. Most patients are older than 60 years of age, and women are affected more often than men. Annular calcification causes mitral regurgitation by displacing the mitral leaflets, by immobilizing the peripheral portion of the mitral leaflets or by impairing the presystolic sphincteric action of the annulus [13].

Carpentier *et al*. classified mitral regurgitation into three pathoanatomic types based on leaflet prolapse or excessive motion: normal leaflet motion (type I), leaflet prolapse or excessive motion (type II) and restricted leaflet motion (type III). Type III is further subdivided into two groups based on leaflet restriction during diastole (type IIIa) or during systole (type IIIb) [9].

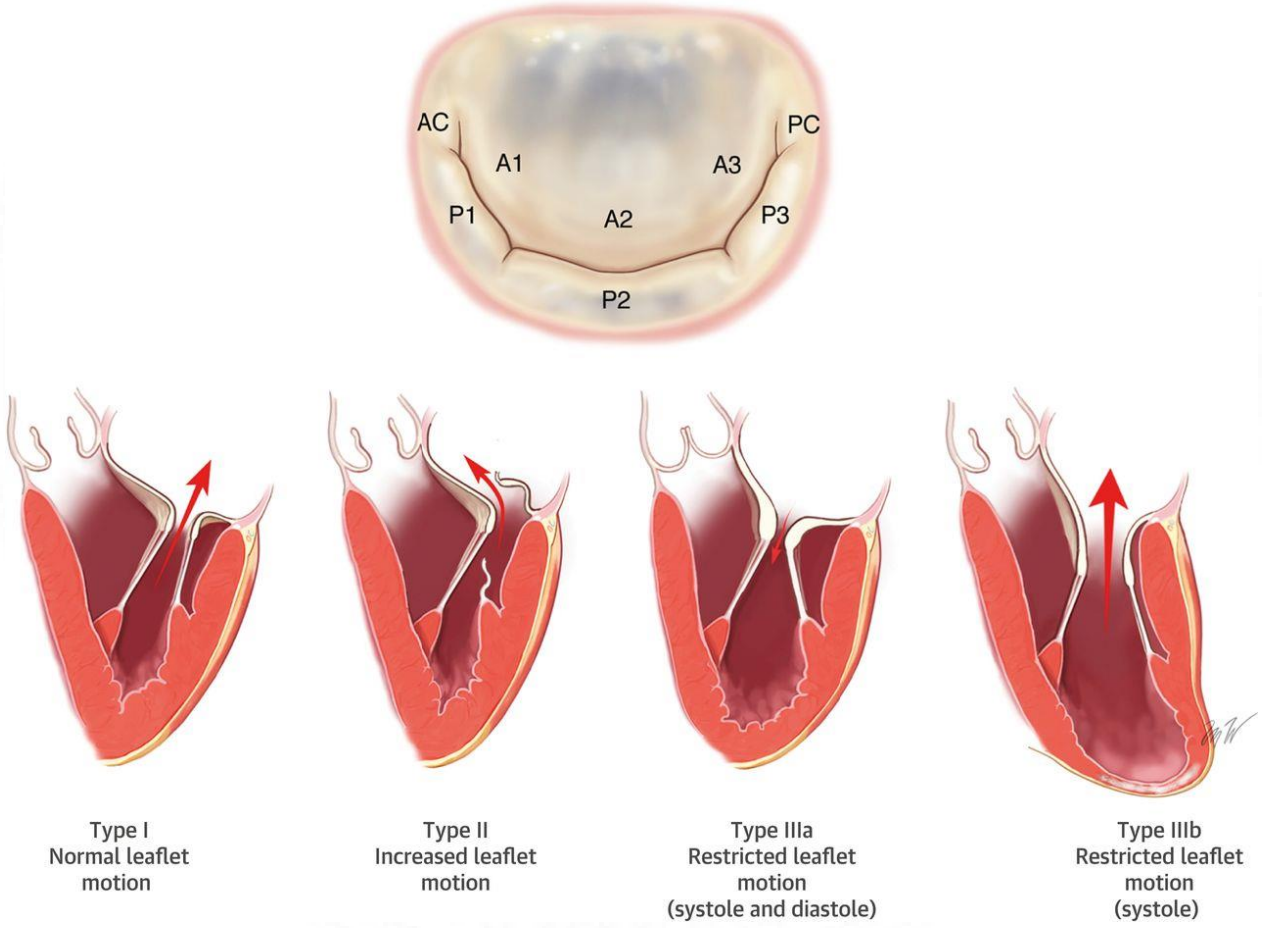


Fig. 5. Carpentier's segmental classification of the mitral valve and functional classification of the types of leaflets and chordal motion associated with mitral regurgitation

Type I MR is present when there is annular dilatation, as in cardiomyopathy, or with leaflet perforation as in endocarditis. Type II MR is caused by elongation or rupture of the chordae tendineae, as often occurs in degenerative disease, or of the papillary muscles, as occurs in ischaemic disease. Type IIIa MR occurs when there is commissural fusion and leaflet or chordal thickening, as seen in rheumatic disease. In type IIIb MR there is chordal retraction (rheumatic) or papillary muscle retraction (ischaemic) or displacement (ischaemic or functional cardiomyopathy) [15].

Pathophysiology

Pathophysiology of acute MR differs markedly from that of chronic MR. Clinical impact of acute mitral incompetence is largely modulated by left atrium compliance. Acute MR results in high left atrial pressure, which can rapidly lead to pulmonary edema. In patients with chronic MR, compensatory changes increase left atrial and pulmonary venous compliance over time so that symptoms of pulmonary congestion may be negligible for several years. In mitral regurgitation, impedance to LV emptying is decreased because the mitral orifice is in parallel with the LV outflow tract. Regurgitation into the left atrium increases left atrial pressure and reduces forward systemic flow. Left atrial pressure rises significantly during ventricular systole, followed by an abrupt decline in early diastole [13]. The most significant change occurring during the evolution from acute to chronic MR is the enlargement of the left ventricle. Despite LV chamber enlargement, preload at the sarcomer level returns to a normal or near normal level [28]. Systolic unloading is gradually replaced by normal systolic wall stresses as the end-systolic volume increases. LV contractility, loading conditions, and ejection fraction remain within the normal range while a large end-diastolic volume is responsible for an enhanced total stroke volume. An enlarged compliant atrium contributes to a decline in pulmonary venous pressures. A very important aspect of the pathophysiology of MR is the nature of the transition from a compensated to a decompensated state. Such a change may occur as a consequence of progressive increments in the regurgitant volume and/or chamber size. This decompensated state is characterized by substantial and progressive ventricular enlargement with increased LV diastolic pressures, increased systolic wall stress, and a decline in the ejection fraction.

The fall in left ventricular ejection fraction is due to both a depressed contractile state and excessive afterload. These changes in LV size and function are often accompanied by progressive atrial enlargement, atrial arrhythmias, pulmonary hypertension, and, eventually, signs and symptoms of congestive heart failure [29].

Clinical Manifestation

The nature and severity of symptoms associated with chronic MR are related to the severity of regurgitation, its rate of progression, the pulmonary artery pressure and associated cardiac disease. Patients with mild to moderate MR may remain asymptomatic with little or no hemodynamic compromise for many years, as there is little volume overload of the ventricle and cardiac hemodynamics and forward cardiac output remain normal. Even in patients with severe MR, most remain asymptomatic until the occurrence of left ventricular failure, pulmonary hypertension or the onset of atrial fibrillation [30].

The compensated phase of MR is variable and may last for many years, but the prolonged burden of volume overload may eventually result in LV dysfunction. Patients with chronic severe MR have a high likelihood of developing symptoms or LV dysfunction over the course of six to ten years [31].

The most common symptoms are exertional dyspnea and fatigue due to the combination of decreased forward cardiac output and an increase in left atrial pressure due to backflow across the mitral valve. Another common clinical presentation is paroxysmal, persistent or permanent atrial fibrillation. Patients with more severe disease and left ventricular enlargement eventually progress to symptomatic heart failure with pulmonary congestion and edema. Other symptoms such as thromboembolism, hemoptysis and right-sided failure do occur, but are less common than with mitral stenosis. There is a high risk for infective endocarditis in patients with an abnormal mitral valve and moderate to severe mitral regurgitation [31].

Clinical assessment of Mitral Regurgitation

Echocardiography

Echocardiography with color flow and spectral Doppler evaluation is an important non-invasive method for assessing Mitral Regurgitation. Echocardiography is essential for establishing valve morphology and function, chamber size, wall thickness, and ventricular function, as well as pulmonary and hepatic vein flow. The initial transthoracic echocardiogram should disclose the anatomic cause of the MR. Multiple parameters from the Doppler examination should be used to diagnose severe MR, including the color flow jet width and area, the intensity of the continuous-wave Doppler signal, the pulmonary venous flow contour, peak early mitral inflow velocity, and quantitative measures of the effective orifice area and regurgitation volume [27]. Three- dimensional echocardiography in patients with mitral regurgitation has been shown to be fairly accurate in elucidating the dynamic mechanism of mitral regurgitation leaks, but only offers qualitative information [13].

Transthoracic imaging is diagnostic in most cases, but if image quality is suboptimal, transesophageal imaging is recommended [32]. Transesophageal echocardiography (TEE) is always indicated to establish the anatomic basis for severe MR in patients in whom surgery is recommended in order to assess the feasibility of repair as well as to guide repair. TEE is not indicated for routine follow-up or surveillance of asymptomatic patients with native valve MR [27].

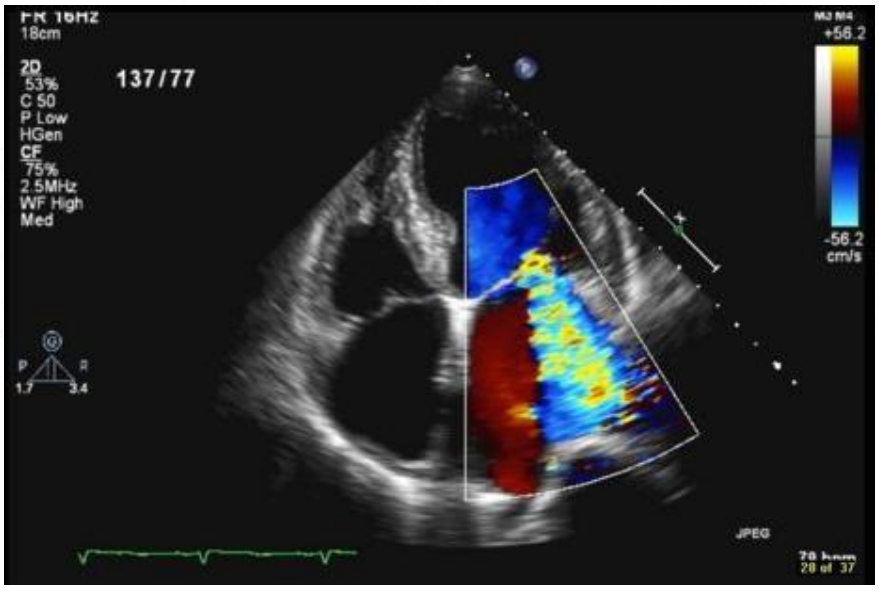


Fig. 6. TEE 4 chamber view showing Mitral regurgitation jet on color flow

Vena contracta is the point in a fluid stream where the diameter of the stream is at its minimum as was first observed and defined by Evangelista Torricelli in the seventeenth century. An echocardiographic measurement of the vena contracta has been shown to provide a good estimate of the severity of the regurgitant orifice area of the mitral valve [33]. An echocardiographic estimation of the proximal isovelocity surface area (PISA) is also currently performed for assessment of the mitral valve regurgitant orifice area [34].

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a non-invasive modality which can be employed to assess the cardiovascular system, including cardiac structure and function [35,36]. MRI and newer advanced techniques, such as moving-slice velocity mapping, control volume method, and real-time colour-flow MRI have been used to evaluate and quantify the degree of mitral regurgitation. The presence of valvular regurgitation can be determined, LV volumes and mitral regurgitant fraction estimated, and information concerning mitral and coronary anatomy obtained.

Treatment

Indications for corrective surgery

Patients with symptoms of severe mitral regurgitation despite normal LV systolic function (ejection fraction greater than 60 % and end-systolic dimension less than 40 mm) require surgery. Surgery should be performed in patients with mild symptoms and severe mitral regurgitation especially if it appears that mitral valve repair can be performed. Mitral valve surgery should also be recommended for symptomatic patients with evidence of LV dysfunction (an ejection fraction equal to or less than 60% and an end-systolic diameter equal to or more than 40 mm) [27].

Surgical treatment is also recommended for asymptomatic patients with severe MR and with signs of left ventricular dysfunction (ejection fraction less than 60% and/or left ventricular end-systolic diameter more than 40 mm). Surgery in this group should be considered to prevent any further deterioration of left ventricular function. Atrial fibrillation

and pulmonary hypertension (a pulmonary systolic pressure of more than 50 mmHg at rest or 60 mmHg on exercise) are also indications for mitral valve surgery in these patients [37].

Surgery for asymptomatic patients with severe MR and normal LV function should be considered if there is a greater than 90 % likelihood of successful valve repair in a center experienced in this procedure [27].

Preoperative atrial fibrillation is an independent predictor of reduced long- term survival after mitral valve surgery for chronic mitral regurgitation [38]. Predictors of the persistence of atrial fibrillation after successful valve surgery are the presence of atrial fibrillation for more than one year and a left atrial size more than 50 mm. Many clinicians consider the recent onset of atrial fibrillation to be an indication in and of itself for surgery, if there is a high likelihood of valve repair [27].

In severe mitral regurgitation secondary to acute myocardial infarction, hypotension and pulmonary edema often occur. Treatment is aimed at hemodynamic stabilization. Revascularization of the coronary artery supplying an ischemic papillary muscle may improve the degree of mitral valve regurgitation. Such an improvement is unlikely on most cases, however, and severe MR requires mitral valve repair with an annuloplasty ring or replacement [27].

Surgical treatment

The most important predictors of postoperative outcome after surgery for mitral regurgitation are symptoms, age, atrial fibrillation, preoperative left ventricular function and the reparability of the valve. Older age increases the operative risks and negatively influences late outcome. It has been reported that the operative mortality for patients in NYHA class I–II was 0% below the age of 75 years and 3– 6% over this age [39]. Pre-operative atrial fibrillation is a predictor of an excess late postoperative morbidity and mortality, while a duration of atrial fibrillation of over one year and a left atrial diameter of more than 50 mm are predictors of permanent postoperative atrial fibrillation.

Major predictors are left ventricular ejection fraction and end-systolic diameter [37]. A preoperative left ventricular ejection fraction less than 50 % is associated with an excess late mortality [38]. The best results of surgery are observed in patients with a preoperative left ventricular ejection fraction more than 60%, a finding which is independent of the type of surgery [37]. While the progressive development of pulmonary hypertension is also a marker for a poor prognosis [27]. The probability of a successful outcome for valve repair is of crucial importance [37]. In multiple studies comparing patients who were managed with medical therapy alone to those who had undergone surgery, the findings indicated that patients treated surgically have had a lower mortality rate. In a cohort with flail mitral leaflet, patients with severe MR treated surgically had 5-and 10-year survival rates no different than expected for age-matched controls, and surgery independently and beneficially influenced survival rate [16].

Surgical Procedures

Two different mitral operations are currently used for the correction of mitral regurgitation: mitral valve repair and mitral valve replacement with or without preservation of part or all the mitral apparatus. In most cases, mitral valve repair is the operation of choice when the valve is suitable for repair and the appropriate surgical skill and expertise are available. This procedure preserves the patient`s native valve without a prosthesis and therefore avoids the risk of chronic anticoagulation or prosthetic valve failure late after surgery. Preservation of the mitral apparatus leads to better postoperative LV function and survival than in cases in which the apparatus is disrupted [27].

The choice of procedure depends upon the cause of the mitral regurgitation, the anatomy of the mitral valve, and the degree of left ventricle dysfunction. The advantages of mitral valve repair over mitral valve replacement include improved long-term survival, a better preservation of left ventricular function, and greater freedom from endocarditis, thromboembolism and anticoagulant-related hemorrhage [14]. With the introduction of standardized surgical techniques [9], mitral valve repair has become reproducible and worldwide performed. In experienced centers, valve repair is currently a feasible surgical option in 70% to 90% of cases of pure or predominant mitral regurgitation and should be feasible in nearly all instances of degenerative mitral valve disease [16].

For proper identification of the location of lesions in the leaflets, a segmental classification has been created. The three scallops of the posterior leaflet are designated as P1 (close to the anterolateral commisure), P2 (the middle scallop), and P3 (close to the posteromedial commisure). The corresponding segments of the anterior leaflet are called A1, A2 and A3. The aim of mitral valve repair is to obtain a valve that no longer leaks, and also to achieve anatomical restoration of all components of the mitral apparatus. Mechanical stress on the valve should be reduced to a minimum. Standard mitral valve repair is based on two main groups of technical steps: to correct any abnormal motion of the leaflets and chordal apparatus and to remodel and stabilize the annulus by implantation of the supporting ring [15].

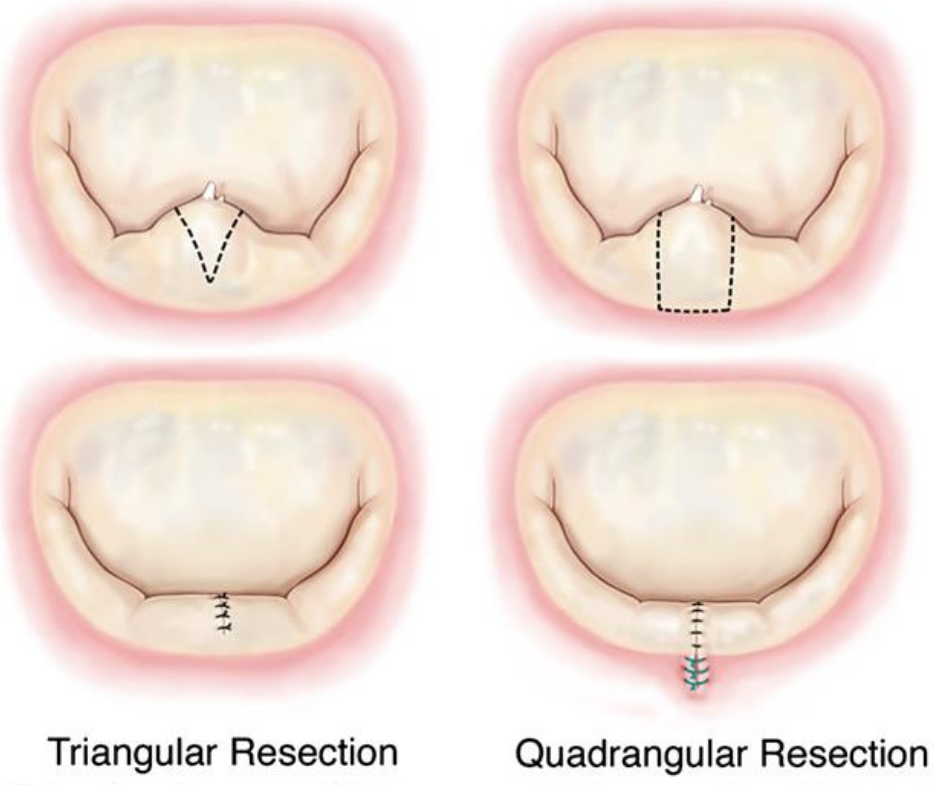


Fig. 7. Surgical technique used to repair a flail segment of the middle scallop of the posterior leaflet

Isolated prolapse of the posterior leaflet is the most frequent lesion leading to mitral regurgitation and accounts for up to 60% of the cases in most surgical series [15]. Prolapse of the posterior leaflet, whether the result of ruptured chordae or elongated chordae, is treated by quadrangular resection of the prolapsing segment, annular plication in the corresponding area, and a subsequent suture of the free edges of the leaflets [9]. The sliding repair of the posterior leaflet, an alternative for posterior annular plication, was devised by Carpentier to prevent left ventricular outflow tract obstruction caused by systolic anterior motion (SAM) of the anterior leaflet of the mitral valve [9]. SAM only occurs in patients undergoing a quadrangular resection for degenerative disease and, before the development of the sliding leaflet repair. SAM could compromise the repair in 5% to 10% of cases [12]. Quadrangular resection of the prolapsing segment may include up to 50% of the length of the posterior leaflet if necessary [12].

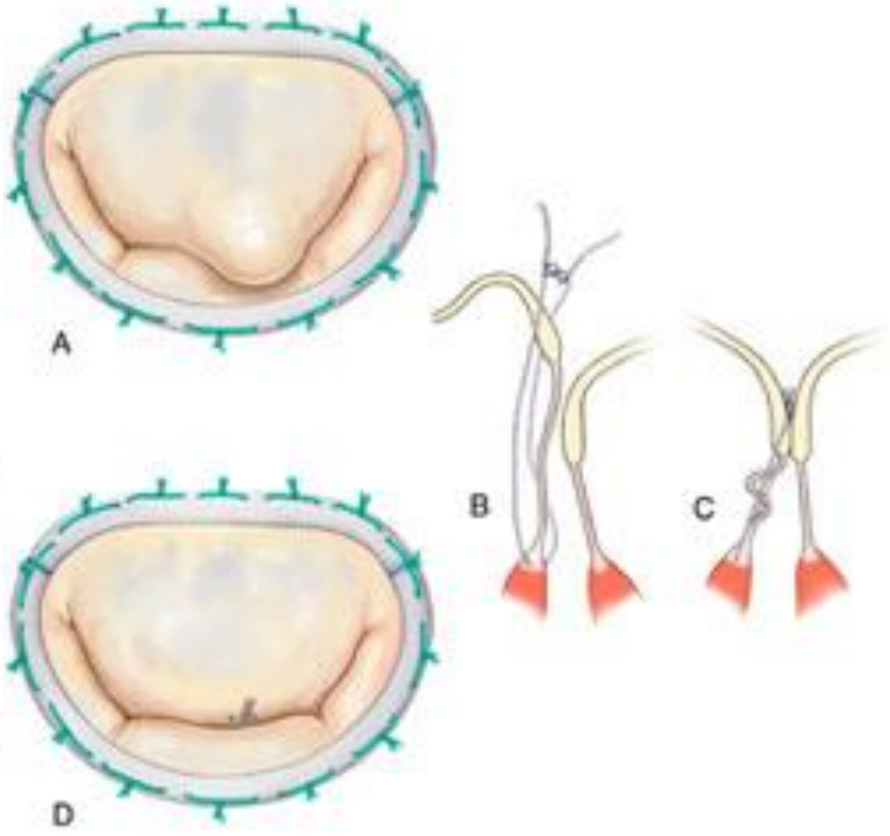


Fig. 8. Surgical technique used to repair a flail segment of the anterior leaflet – Annuloplasty and Neochordal reconstruction

Prolapse of the anterior leaflet requires a different technique for repair. This situation is usually the result of elongation or rupture of the anterior leaflet chordae. Anterior leaflet resection is rarely indicated, because there may not be enough tissue for reconstruction of the leaflet [15]. Carpentier described two techniques effective for restoring normal motion in the leaflet. The first is chordal or papillary muscle shortening and the second technique is chordal transfer [9]. David was one of the pioneers who used polytetrafluoroethylene (PTFE) sutures as neochordae [40]. Annular enlargement is quite common in patients with degenerative disease. This usually only occurs along the posterior annulus. Annuloplasty is performed to correct annular dilatation, increase leaflet coaptation, reinforce suture lines, and prevent further dilatation. Annuloplasty rings may be flexible or rigid, complete or incomplete [12].

Fig. 9. Alfieri technique used to repair a flail segment of anterior leaflet

In 1995, Alfieri *et al*. described the edge-to-edge repair which is also called double orifice repair [41]. When employed to correct anterior leaflet prolapse, a suture affixes the free edge of a segment of the normal posterior leaflet to the free edge of a prolapsing portion of the anterior leaflet. The normal posterior leaflet with its chordae serves to anchor the anterior leaflet, restricting its excessive motion [41]. Satisfactory mid-term results with this technique have been reported [42].

Functional MR is generally manageable with annuloplasty alone. Functional MR may be corrected by placement of an annuloplasty ring which decreases the annular circumference, shortens the intertrigonal distance, reduces the septal- lateral (anterior-posterior) annular diameter, and restores the geometry of the annulus, thereby allowing the mitral valve leaflets to coapt. The precise choice of the type of annuloplasty (flexible vs. rigid, complete vs. incomplete) is still controversial [(43)].

Annuloplasty Rings

Innovation of flexible annuloplasty rings by Dr. Carlos M. G. Duran for dynamic annulus, significantly improved the out of MV repair surgery [(44)]. Patients with regurgitant myxomatous mitral valves that underwent repair with a ring had a 3.6% recurrence rate, which contrasts with a recurrence rate of 15% for valves that underwent repair without a ring [(45)]. This indicated need for annuloplasty rings in myxomatous MV disease. Since then lot of advancement in annuloplasty rings along with techniques of surgery have taken place from minimally invasive repair to robotic assisted repair, but use of annuloplasty ring has been standard.

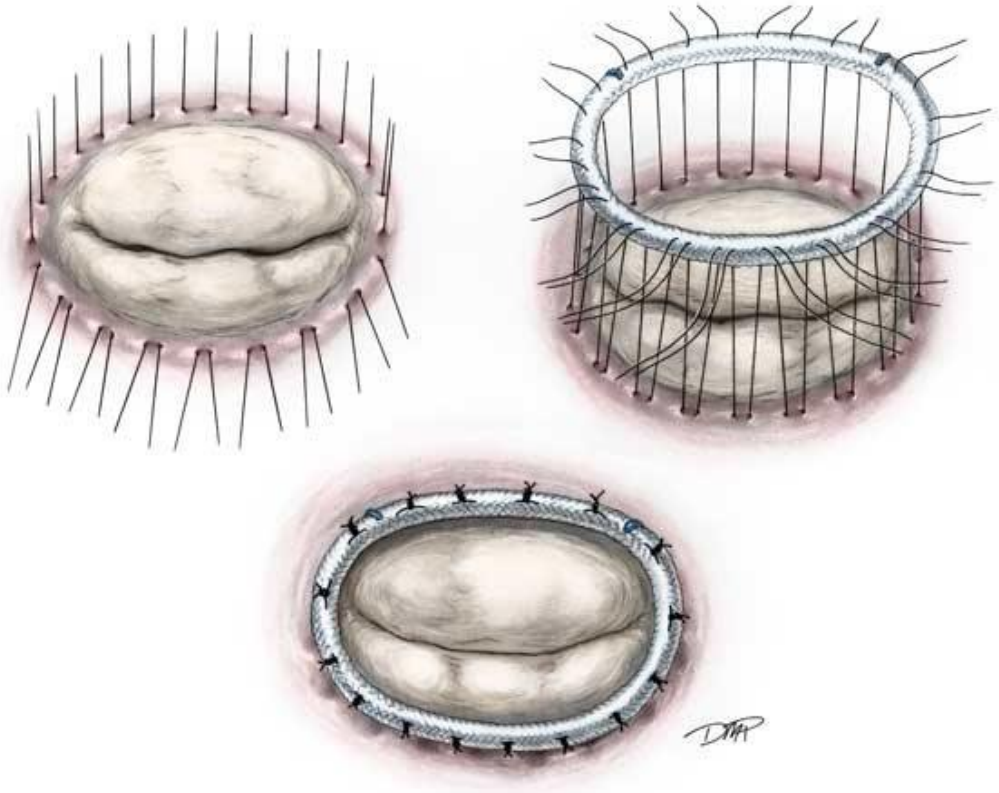


Fig. 10. Prosthetic ring Annuloplasty for repair of Myxomatous Mitral Valve

Choice of ring and appropriate sizing is always a Probing challenge for surgeon. Inappropriate ring sizing may cause poor outcome of surgery. Earlier reports of mismatch in dimensions of sizer's and Rings along with Mislabeling have been reported [46].

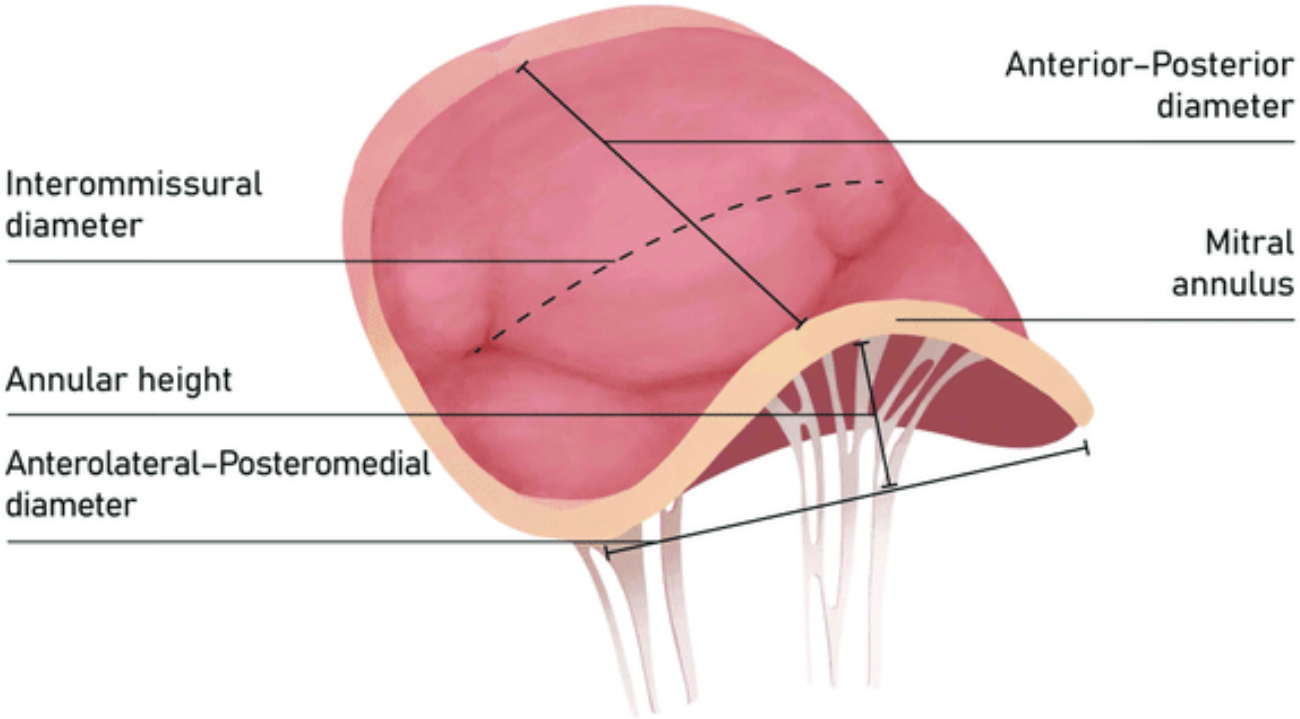


Fig. 11. Diameters of Mitral Valve describing the prosthetic ring size

Further adding on to confusion with multiple sizes and dimensions, one has to match the anatomic dimensions. Described anatomic dimensions for a particular ring may be difficult to identify precisely. This is experienced for intercommissural and intertrigonal distance especially. In Barlow's disease, locating the commissures may be hindered by floppy leaflet tissue. Also, although commissures are usually distinctly developed, sometimes be incomplete. Fibrous trigones may also be difficult to locate accurately in any disease state. Okamoto and colleagues also had a similar opinion about anatomical dimensions [47]. Choo and associates [48] also quoted that "accurate identification of the trigonal structures, which is crucial in selecting the proper ring size, cannot always be made with certainty."

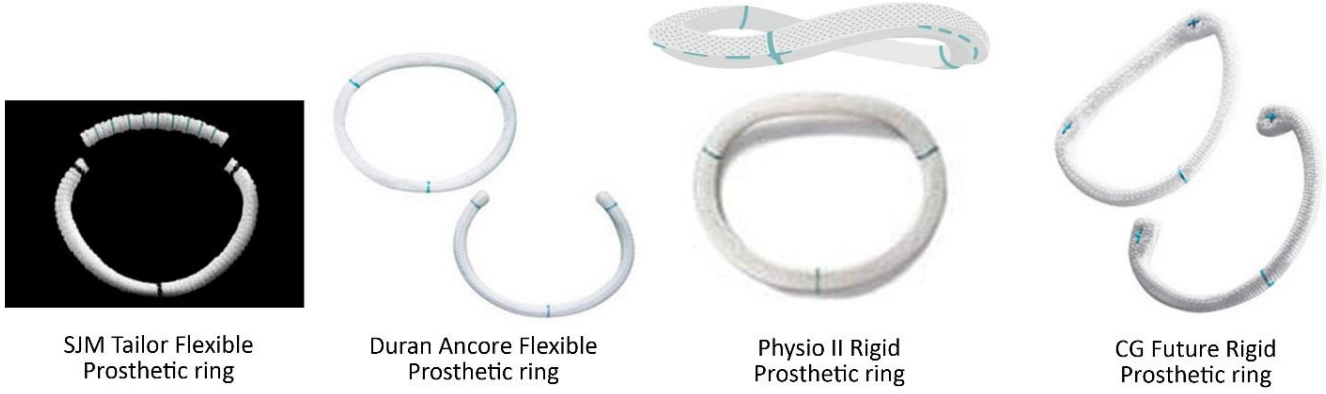


Fig. 12. Types of Prosthetic rings used for Mitral repair in our study population

In present study, we looked for any other parameter which influenced the ring size and outcome of MV repair in long term. Avoidance of Patient Prosthetic Mismatch is important for selection of prosthetic aortic valve. So, determination of the effective orifice area index (EOAI), which includes consideration of the Body Surface Area (BSA) is mandatory in patients undergoing aortic valve replacement [(49)]. Conversely, the EOAI is not normally used for selection of a prosthetic mitral valve / Ring because the transmitral pressure gradient can easily increase during exercise. Moreover, strong evidence to support use of the EOAI in this setting is currently lacking.

Down sized mitral annuloplasty has been reported to cause functional mitral stenosis, which may cause pulmonary hypertension and decreased functional capacity [(50)]. Even in the normal heart, the transmitral pressure gradient is highly dependent on transvalvular flow and diastolic filling period. This gradient greatly varies with changes in heart rate, and is an important predictor of functional capacity [(51)].

While too larger mitral annuloplasty will have residual insufficiency and poor results in long term. This is due to LV-MV ring size mismatch associated with increased risk of MR recurrence [(52)]. Functional mitral stenosis caused by smaller ring annuloplasty may result in elevated left atrial pressure and left atrial wall shear stress in patients with degenerative Mitral insuffuciency. Which in turn, is reported to have poor outcome of MV repair in long term. Therefore, down-sizing ring annuloplasty should be avoided in patients with degenerative Mitral insuffiency [(53)]. Carpentier et al. suggested that a larger prosthesis should be chosen when the native valve size is between two sizes of prosthesis, except in patients with type IIIb dysfunction [(54)].

RESULTS

Statistical Analysis

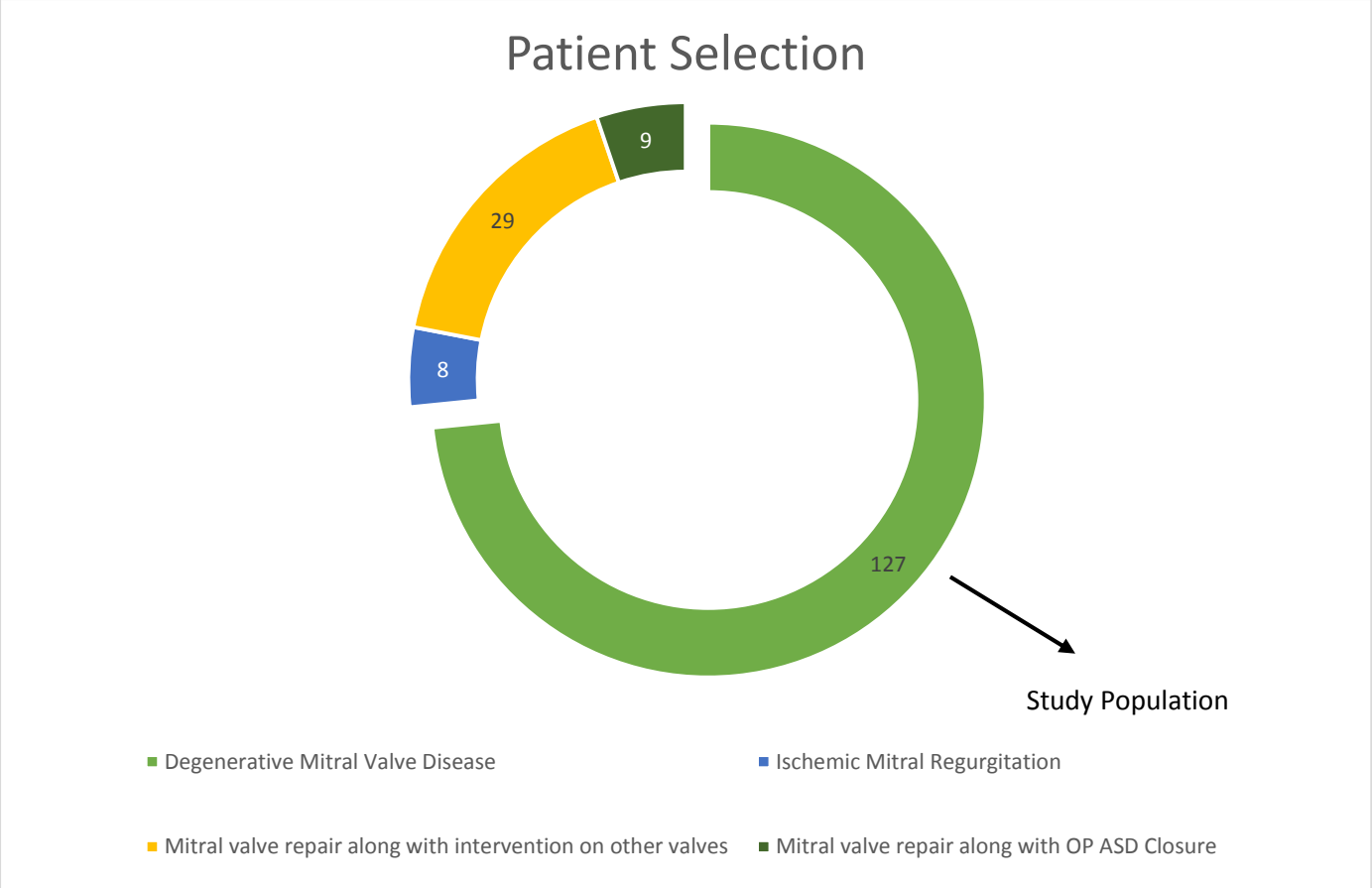
Data were imported and analysed using Microsoft Excel, SPSS 27.0 software. Continuous variables were compared using the nonparametric Wilcoxon test and are presented as mean ± SD. Nominal and categorical values were compared using the x^2 likelihood ratio or Fisher's exact tests. Univariate and multivariate Cox proportional hazard functions were used to determine predictors for complications. Linear regression was used to compare the degree of MR as a function of postoperative interval. Kaplan Meier Survival Curve was used for Event free Survival after 5 years of Surgery.

Predictors for outcomes found to be of statistical significance by univariate analysis were subject to stepwise multivariate logistic regression to determine predictors for recurrence of postoperative MR.

Patient Selection

Total of 173 patients underwent Mitral valve repair during 2012 – 2016. Among the 173 patients 127 patients underwent Mitral Valve repair alone for Degenerative Mitral Valve disease. 8 patients for Ischemic Mitral regurgitation. 29 patients had intervention on other valves along with Mitral Valve repair. 9 patients underwent Mitral valve repair for Congenital / along with Ostium primum ASD Closure.

127 patients fulfilled Inclusion and Exclusion criteria of our study and were considered for follow up.



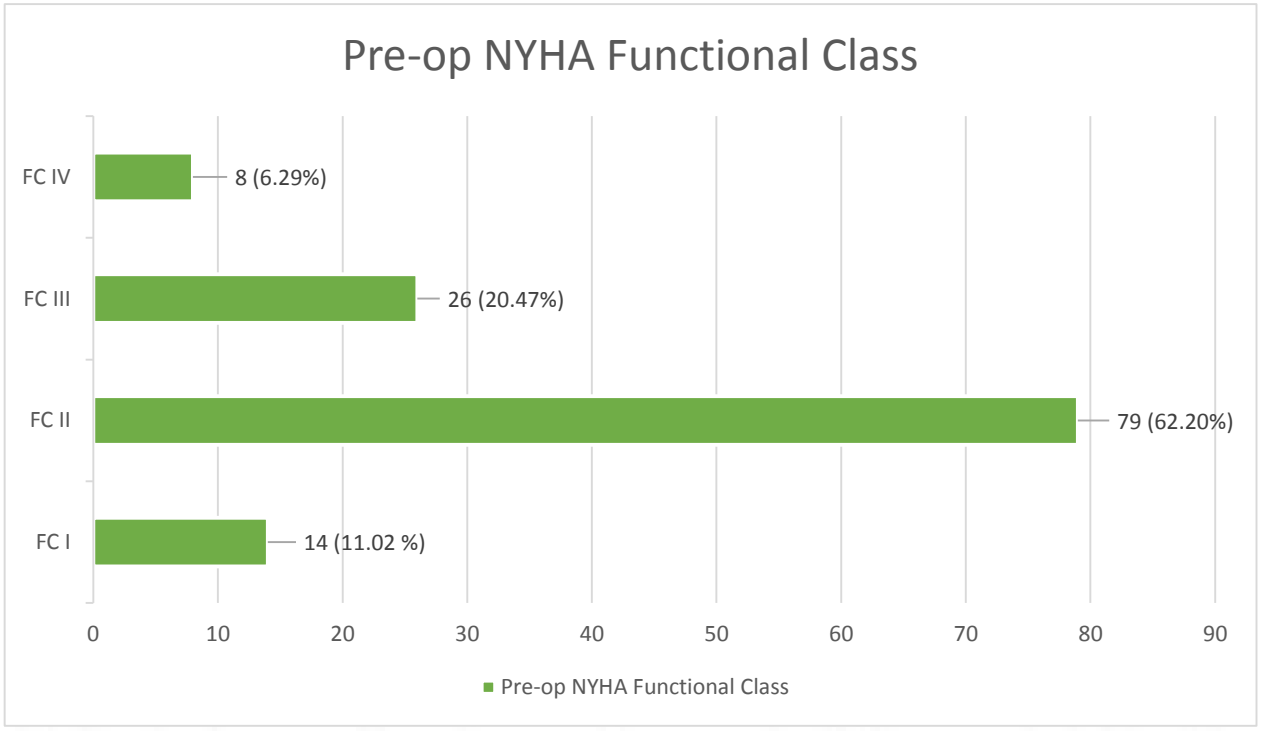
Graph 1: Patient Selection and Study Population

Pre – Operative Patient Characteristics

VARIABLES	NO. (%) / MEAN ± SD
AGE	38.3 ± 6.82
MALE / FEMALE	78 (61.41 %) / 49 (38.58 %)
BODY SURFACE AREA (m^2)	1.68 ± 0.26
PRE OPERATIVE NYHA FUNCTIONAL CLASS	
I	14 (11.02 %)
II	79 (62.20 %)
III	26 (20.47 %)
IV	8 (6.29 %)
PRE OPERATIVE PRESENCE OF ATRIAL FIBRILLATION	16 (12.59 %)
PULMONARY HYPERTENSION STATUS PREVIOUS TO MV REPAIR	
NO	7 (5.51 %)
MILD	65 (51.18 %)
MODERATE	36 (28.34 %)
SEVERE	19 (14.96 %)
SEVERITY OF MITRAL REGURGITATION	
MR II +	4 (3.14 %)
MR III +	19 (14.96 %)
MR IV +	104 (81.88 %)
MITRAL VALVE PATHOLOGY	
ANNULAR DILATATION	2 (1.57 %)
ANTERIOR LEAFLET PROLAPSE	18 (14.17 %)
POSTERIOR LEAFLET PROLAPSE	63 (49.60 %)
BOTH ANTERIOR & POSTERIOR LEAFLET PROLAPSE	16 (12.59 %)
LEAFLET PROLAPSE ALONG WITH RUPTURED CHORDAE	25 (19.68 %)
CALCIFIC ANNULUS	3 (2.36 %)
ASSOCIATED TRICUSPID REGURGITATION MILD - MOD	46 (36.22 %)
LEFT VENTRICULAR EJECTION FRACTION (%)	49 ± 8 %
LEFT VENTRICULAR END DIASTOLIC DIAMETER (mm)	60.57 ± 11.35
LEFT VENTRICULAR END SYSTOLIC DIAMETER (mm)	35.93 ± 6.39

Table 1: Pre-Operative Patient Characteristics

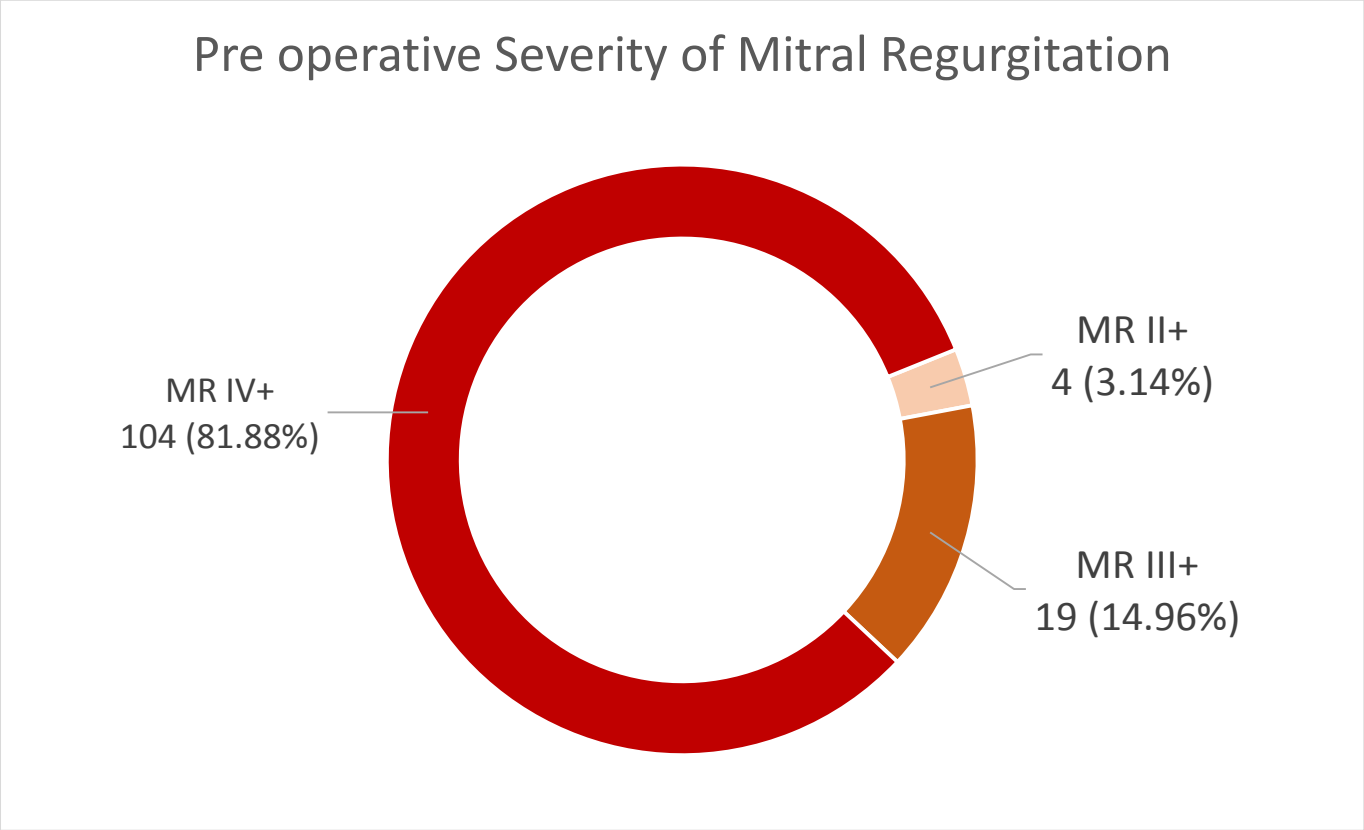
Pre-Operative NYHA Functional Class



Graph 2: Distribution of Study Population according to Pre-Operative NYHA Functional Class

79 (62.20 %) patients were in NYHA Functional Class II on presentation for surgery, which formed major group. Followed by 26 (20.47 %) patients in NYHA Functional Class III and 8 (6.29 %) patients were in NYHA Functional class IV. 14 (11.02 %) patients were in NYHA Functional class I. Most of the patients were on Medical management before being referred for surgery.

Pre-Operative Severity of Mitral Regurgitation



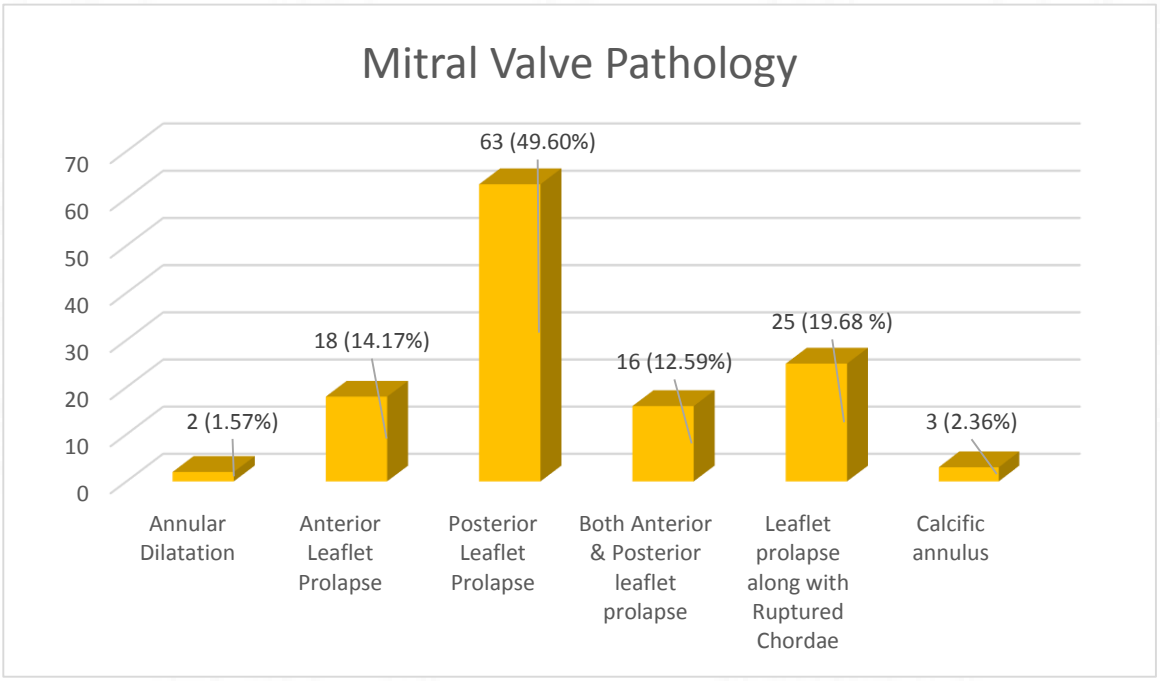
Graph 3: Distribution of Study Population according to Pre-Operative Severity of Mitral Regurgitation

During evaluation for severity of Mitral regurgitation pre-operatively with ECHO 104 (81.88%) patients were found to have MR IV +. 19 (14.96%) patients had MR III + and 4 (3.14 %) patients had MR II + but indicated for surgery due to persistent symptoms and did not improve in Functional class after medical management.

Operative techniques

Operations were performed through median sternotomy. Following aorto- bicaval cannulation. Patient was taken into cardiopulmonary bypass with moderate hypothermia (30-32°C). Myocardial protection obtained by cold antegrade root cardioplegia combined with topical cooling.

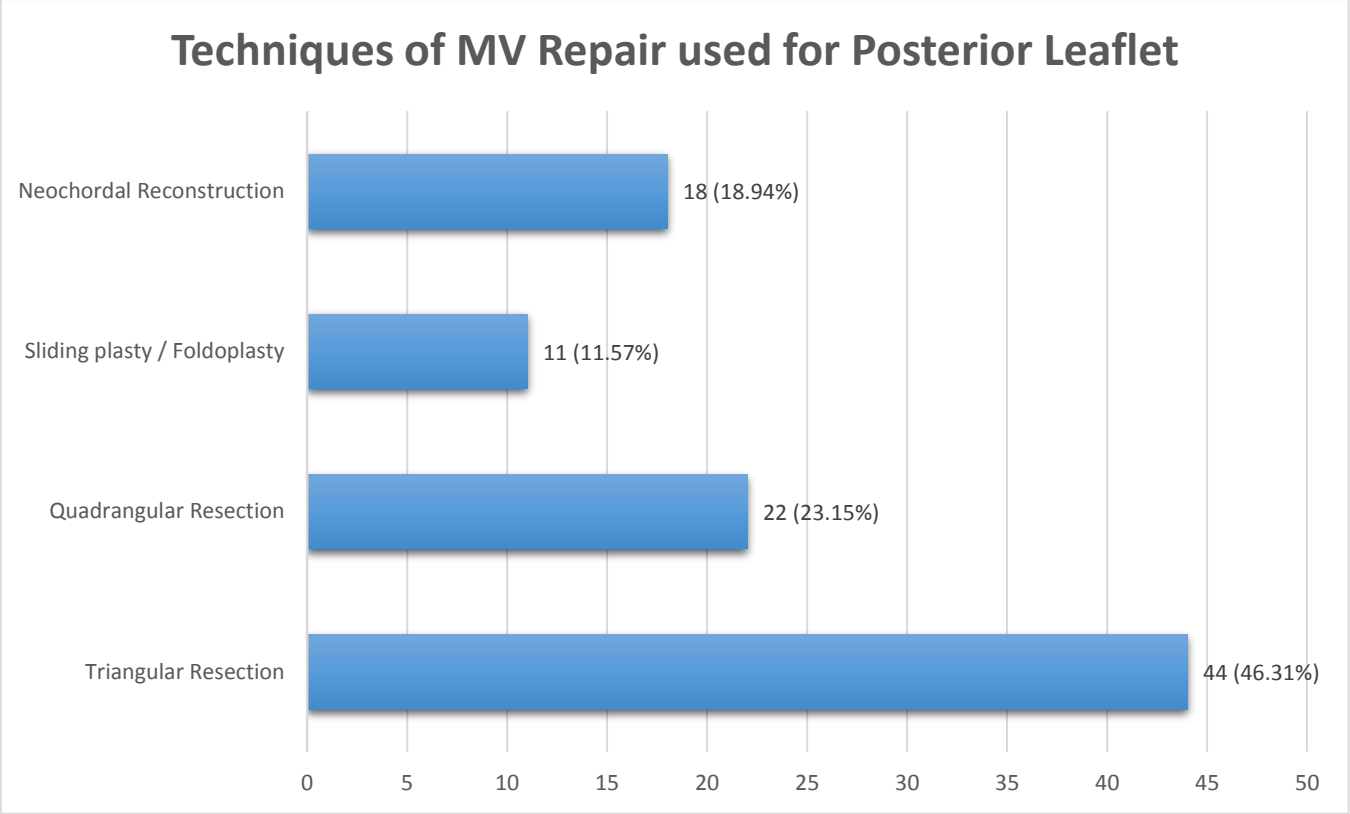
Mitral valve was exposed by standard left atriotomy. Valve analysis showed that 63 (49.60 %) of the patients in the study population had posterior leaflet prolapse as prevalent mechanism of MR, which was the most. It was followed by Leaflet prolapse along with ruptured chordae in 25 (19.68 %) of patients. Anterior leaflet prolapse for mechanism of MR was found in 18 (14.17 %) of patients. 16 (12.59 %) of patients had Bileaflet prolapse, whereas 3 (2.36 %) were noted to have Calcific annulus as contributor for MR. 2 (1.57 %) patients were noted to have annular dilation with normal leaflets.



Graph 4: Distribution of Study Population according to Mitral Valve Pathology causing MR

Techniques of MV Repair used for Posterior leaflet causing MR

95 out of 127 patients underwent one of the below techniques for Repair of Posterior Leaflet involving Posterior leaflet Prolapse / Bileaflet prolapse / Ruptured Chordae.

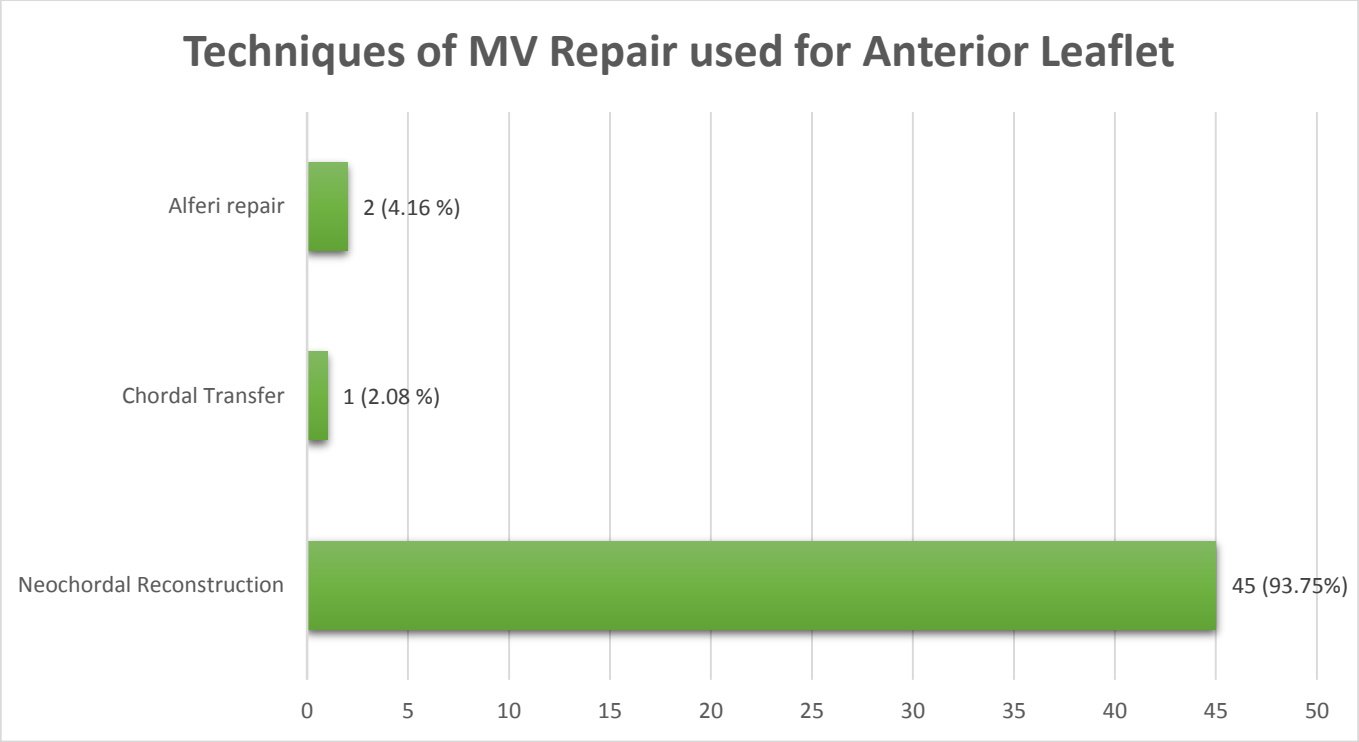


Graph 5: Distribution of Patients according to techniques used for repair of Posterior leaflet causing MR

Triangular Resection was the most preferred technique in 44 (46.31 %) patients who underwent Posterior leaflet Repair, followed by Quadrangular resection in 22 (23.15 %) patients. Neochordal reconstruction with PTFE suture was done in 18 (18.94 %) patients and Sliding / Foldoplasty was done in 11 (11.57 %) patients.

Techniques of MV Repair used for Anterior leaflet causing MR

48 out of 127 patients underwent one of the below techniques for Repair of Anterior Leaflet involving Anterior leaflet Prolapse / Bileaflet prolapse / Ruptured Chordae.

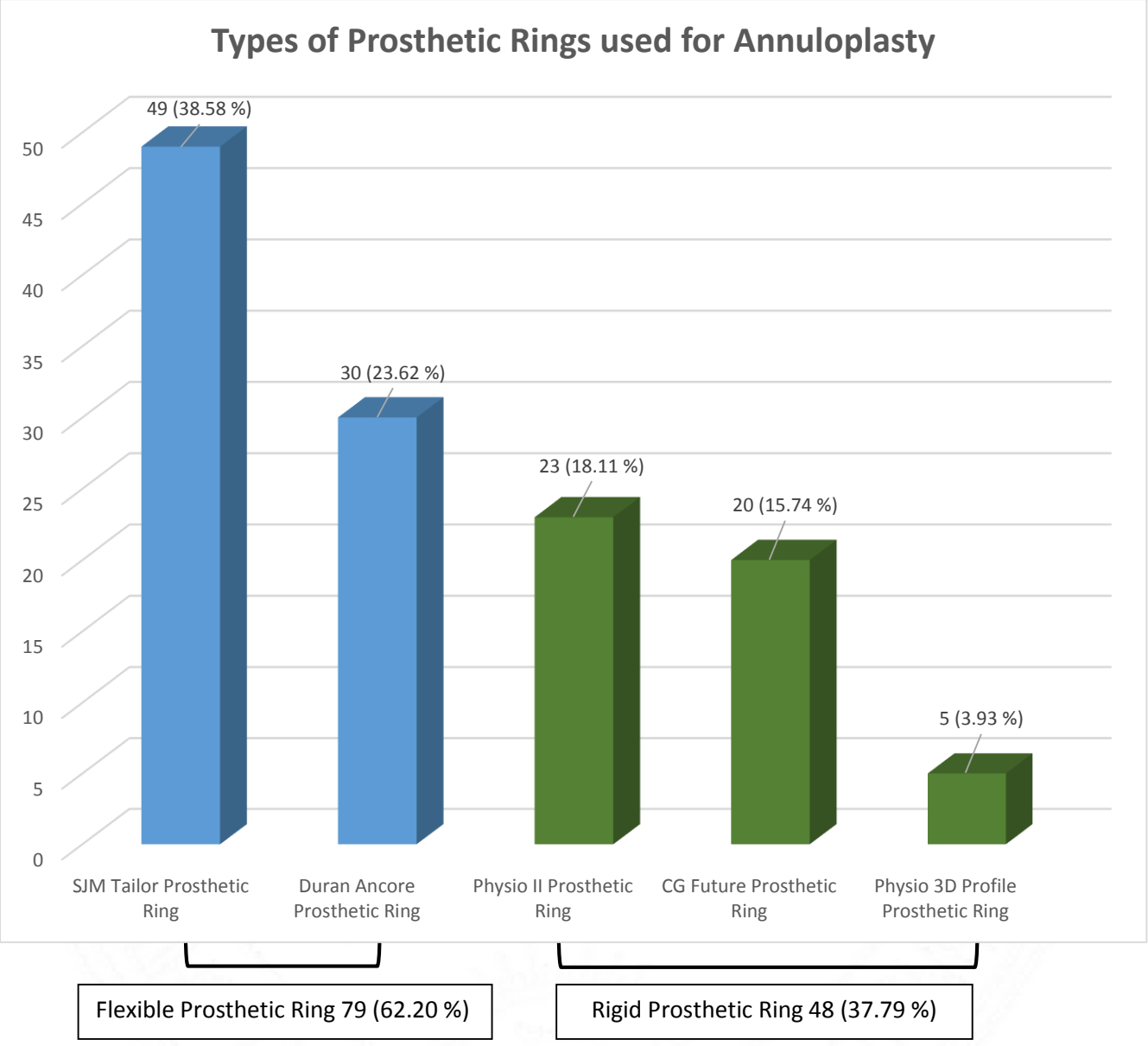


Graph 6: Distribution of Patients according to techniques used for repair of anterior leaflet causing MR

Neochordal reconstruction with PTFE suture was the most preferred technique in 45 (93.75 %) patients who underwent Anterior leaflet Repair. Chordal transfer was done in 1 patient and Alferi repair in 2 patients.

Annuloplasty Ring

All 127 patients underwent annuloplasty with help of prosthetic ring. Both Flexible and Rigid Prosthetic rings were used from different manufactures.



Graph 7: Distribution of Patients according to type of Prosthetic ring used for annuloplasty

79 (62.20 %) patients underwent annuloplasty with Flexible Prosthetic ring, among that SJM Tailor Prosthetic ring was the most preferred prosthetic ring in 49 (38.58 %) patients and rigid prosthetic ring was used in 48 (37.79 %) patients and Physio II Prosthetic ring was the most preferred in 23 (18.11 %) patients.

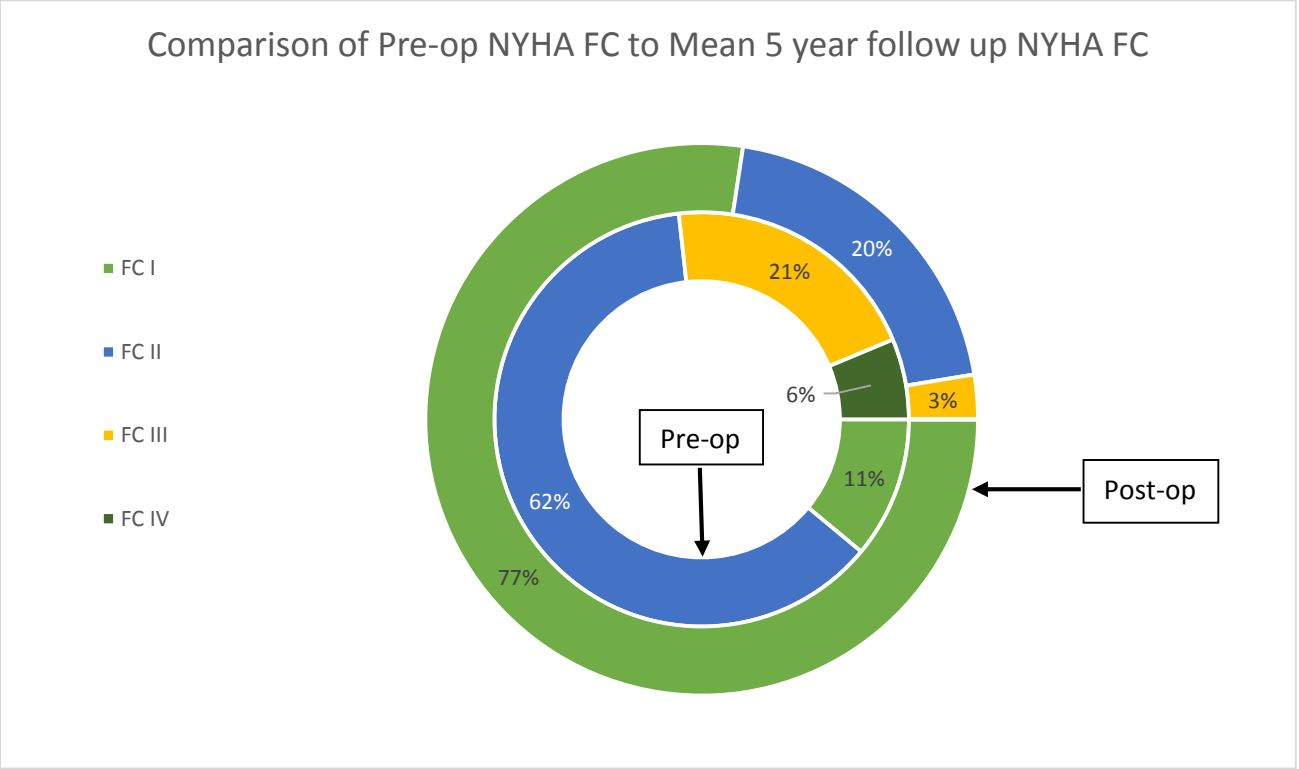
Post – Operative Patient Characteristics

12 (9.44 %) patients were lost to follow up of our hospital and 115 patients were followed up during mean 5 year follow up.

	IMMEDIATE POST OP	FOLLOW UP AFTER 5 YEARS
VARIABLES	No. (%) / Mean ± SD	No. (%) / Mean ± SD
NO. OF PATIENTS	127	115 (12 patients were lost to follow up)
POST OPERATIVE NYHA FUNCTIONAL CLASS		
I	94 (74.01 %)	89 (77.39 %)
II	26 (20.47 %)	23 (20.00 %)
III	6 (4.72 %)	3 (2.60 %)
IV	1 (0.78 %)	0 (0.0 %)
PULMONARY HYPERTENSION STATUS POST MV REPAIR		
NO	99 (77.95 %)	104 (90.43 %)
MILD	23 (18.11 %)	9 (7.82 %)
MODERATE	5 (3.93 %)	2 (1.73 %)
SEVERE	0 (0.0 %)	0 (0.0 %)
MITRAL REGURGITATION POST MV REPAIR ON FOLLOW UP		
MR I +	79 (62.20 %)	41 (35.65 %)
MR II +	43 (33.85 %)	65 (56.52 %)
MR III +	3 (2.36 %)	9 (7.82 %)
MR IV +	2 (1.57 %)	0 (0.0 %)
TRICUSPID REGURGITATION POST MV REPAIR ON FOLLOW UP		
TR I +	94 (74.01 %)	91 (79.13 %)
TR II +	33 (25.98 %)	24 (20.86 %)
TR III – IV +	0 (0.0 %)	0 (0.0 %)
LEFT VENTRICULAR EJECTION FRACTION POST MV REPAIR ON FOLLOW UP (%)	57 ± 6 %	53 ± 9 %

Table 2: Post - Operative Patient Characteristics

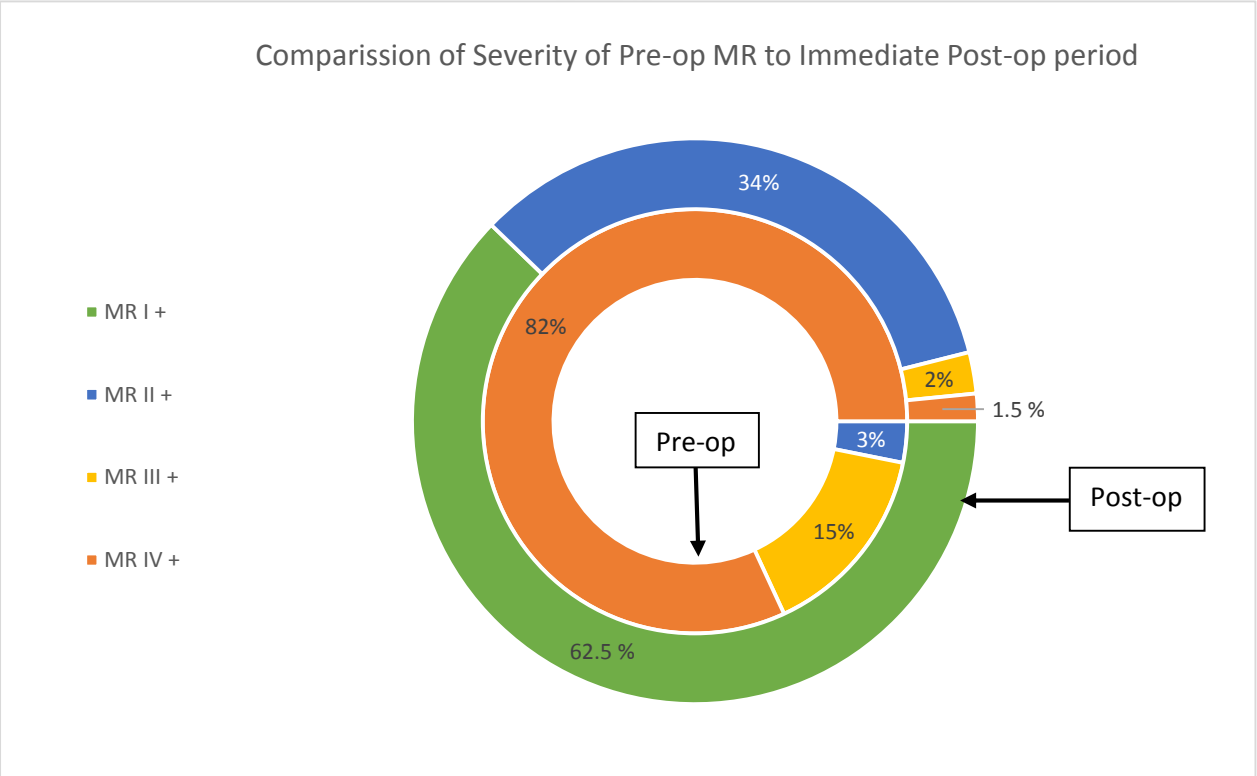
Comparison of Pre-op NYHA FC to Mean 5 year follow up NYHA FC



Graph 8: Comparison of Pre-op NYHA FC (Inner ring) to Mean 5 year follow up NYHA FC (Outer ring)

Results showed there was significant improvement in NYHA Functional Class even at 5 year mean follow up period. 77 % of patients ($p < 0.01$) of study population remained in NYHA FC I during 5 year mean follow up period, which was at 11 % when compared to pre-operative period.

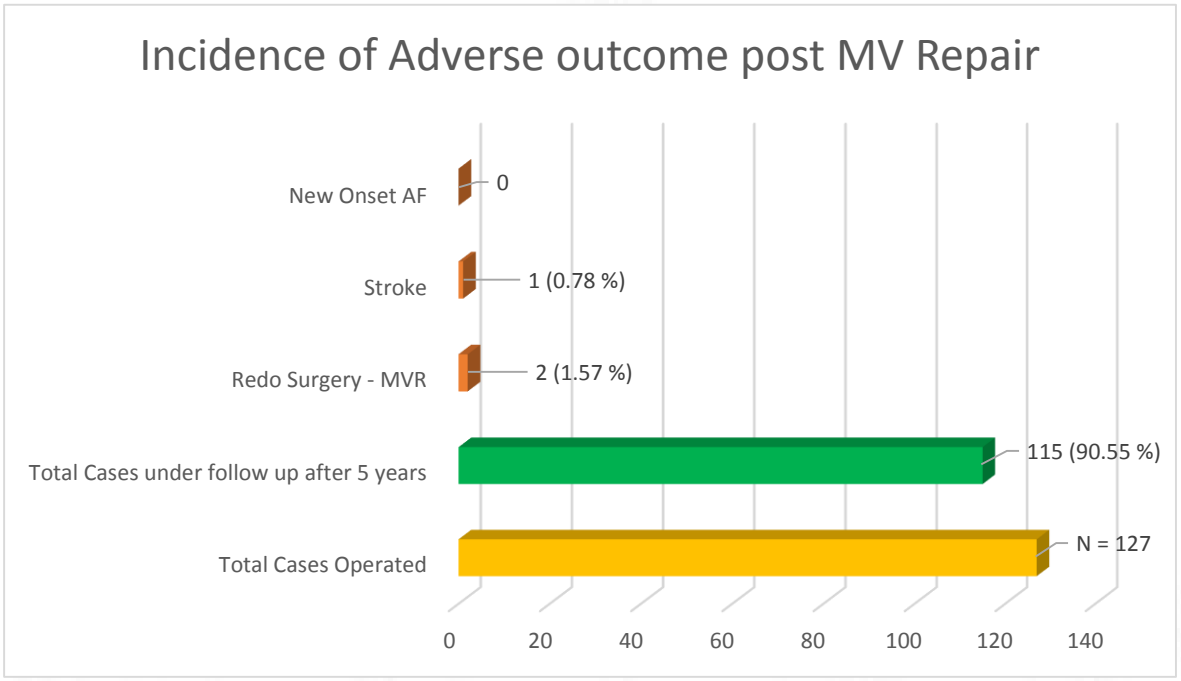
Comparison of Severity of Pre-op MR to Immediate Post-op period



Graph 9: Comparison of Severity of Pre-op MR (Inner ring) to Immediate Post-op period (Outer ring)

Results showed there was significant improvement in Mitral regurgitation status Post MV Repair. 62.5 % of patients had Trivial MR post MV Repair ($p < 0.001$). 34 % of patients had Mild MR Post MV Repair. 2 patients had recurrence of Severe MR post MV Repair and underwent MV Replacement for the same.

Complications post MV Repair



Graph 10: Interpreting Incidence of Adverse outcome post MV Repair

Redo Surgery

2 Patients had Severe MR IV + during immediate post op period post MV Repair and underwent Redo Surgery with Mitral Valve Replacement during the same hospital admission.

Incidence of Morbidity and Mortality

There was no mortality noted in our study during immediate post-operative period or in followed up patients.

One Patient suffered Stroke due to Deranged INR, who was on Anti Coagulation for AF. Patient recovered with Medical management and has minimal residual defects on follow up. We found no significant correlation with CVA and MV repair for myxomatous mitral valve disease.

Cardiac Rhythm

Majority of patients in study were in Sinus Rhythm prior to surgery (n = 111) and also during post op follow up period. They received Warfarin / Acitrom for a period of 3 months and then medication was discontinued. No new onset of AF was diagnosed during follow up period. Remaining study population with AF (n = 16) were continued on Anti Coagulation and regular monitoring of INR was done. We found no correlation between atrial fibrillation and MV repair for myxomatous mitral valve disease.

Infective Endocarditis

None of the patients in our study population suffered from infective endocarditis during immediate post-op or follow up period. We found no correlation between Infective Endocarditis and MV repair for myxomatous mitral valve disease.

DISCUSSION

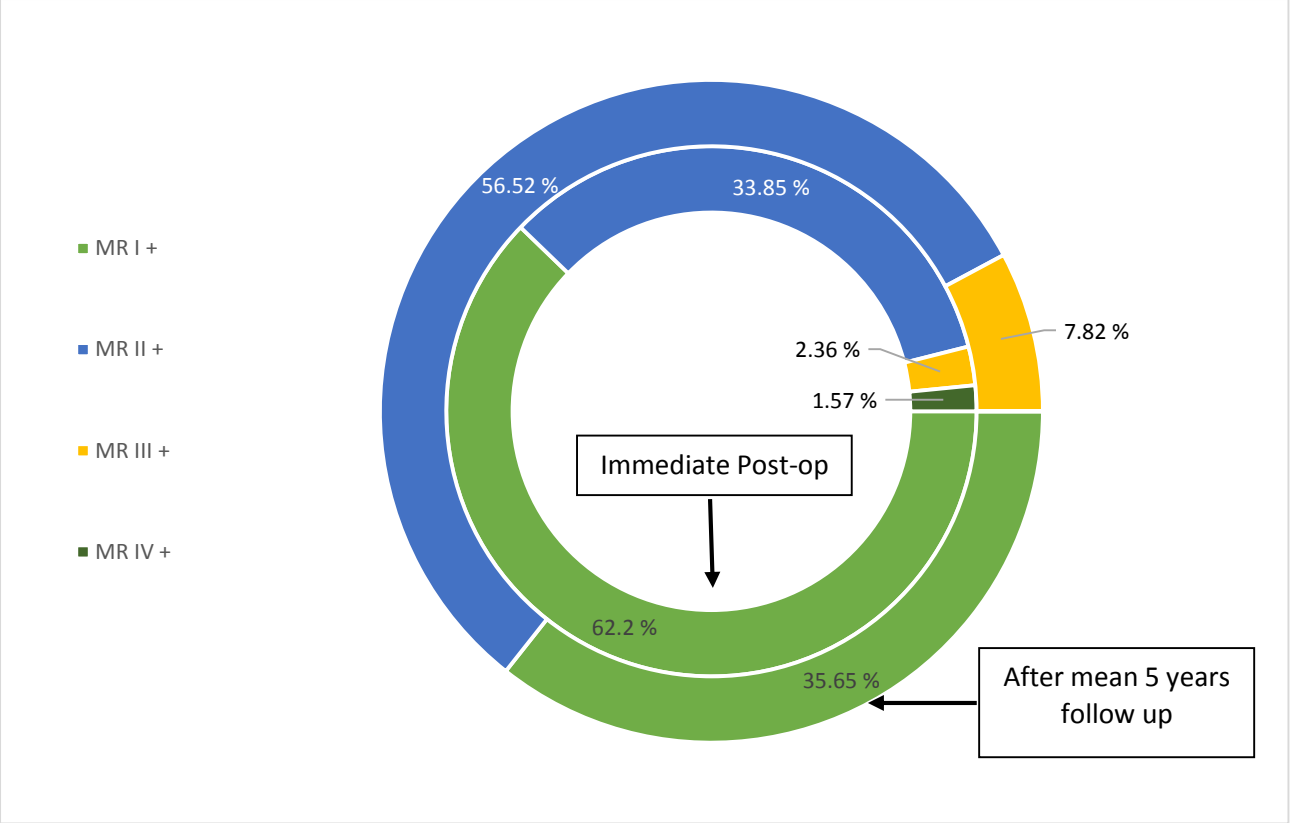
In this current era, Mitral Valve (MV) repair is the operation of choice for Mitral insufficiency due to myxomatous degenerative pathology of MV [55]. MV repair for insufficiency was first done as early as in 1957 by Dr. C. Walton Lillehi at University of Minnesota [3,4]. In next few years, Modern techniques for MV repair was brought into light by Dr. Dwight C. McGoon of the Mayo Clinic in 1960 [5]. A technique to repair a ruptured cord in the posterior leaflet of the mitral valve was described. In 1983, Dr. Alan F.Carpentier presented a game changing paper "The French Correction" [9]. His paper gave the basic pathophysiological classification of mitral valve lesions and essentially a pre-operative plan for how to successfully and reproducibly repair mitral valve insufficiency, particularly from degenerative myxomatous MV disease.

Key principles for repair of the myxomatous mitral valve is to address anatomical problem first. Once this is done, one should resist the temptation to do more than one needs "less is more" [56]. This present study is a Retrospective Observational study with Prospective follow up of patients. Various authors have compared Mitral valve repair with Replacement, but Long term results are still under evaluation for Mitral valve repair.

Repeat cardiac procedure is a well-known risk factor in cardiac surgery and for quality of life, so in view of it reviewing the patients who underwent Mitral valve repair is critical. We have followed up 127 patients who underwent Mitral valve repair for Degenerative Mitral Valve disease and was operated for Mitral regurgitation. Immediate post-operative results are all encouraging with no mortality or morbidity due to surgery. 2 patients had to undergo Mitral valve replacement during same hospital admission, due to recurrence of Severe MR post MV Repair.

Progression of MR, Freedom from reoperation, Freedom from thromboembolic event, Freedom from Infective endocarditis and survivability with Functional class of patients have been evaluated during the follow up period. 12 patients were lost during mean follow up period of 5 years.

Progression in Severity of MR during mean 5 year follow up



Graph 11: Progression of severity of MR from immediate post-op period (Inner ring) to mean 5 year follow up period (Outer ring)

In this study we found majority of patients during five year follow up to have Trivial MR I + to Mild MR II +, 62.2 % of patients had Trivial MR during immediate post-operative period, whereas at the time of 5 year mean follow up period 35.65 % had trivial MR. There was increase in patients having Mild MR II + at 5 year mean follow up period from 33.85 % to 56.52 %. All these patients had better functional class status after 5 years and were asymptomatic. Our freedom from progression to Severe MR III – IV + was 92 %. Our result was in line with other studies of Nardi et al. [57], which showed that in their series of 10 year follow up freedom from progression to severe MR was 85% and a study by Gaur et al. [58] reported it to be 98.5%.

In our series, 3 Patients who underwent Mitral repair for anterior leaflet prolapse, 1 patient for Posterior leaflet prolapse and 3 patients for Bileaflet prolapse had progression to MR III +. Similar results were found in study done by David TE et al. [59] where freedom from severe recurrent MR at 12 years was 86% for patients with anterior leaflet prolapse, 92% for patients with Posterior Leaflet prolapse, and 86% for patients with Bileaflet prolapse. A study by De Bonis et al [60] found freedom from recurrent severe MR at 97.8 % for patients with Anterior Leaflet prolapse and 100% for patients with Posterior Leaflet prolapse at 15 years follow up.

Freedom from Reoperation

Our study showed a freedom from re operation of 98.45% at mean follow up of 5 years. Only 2 patients underwent Redo MVR during immediate post-operative period for failure of MV repair. No other patients underwent redo surgery in long term. Similar results were also reflected in other published results of Nardi et al. (95%) [57] and Gaur et al. (96%) [58]. A systematic review of Long term outcomes of Mitral Valve Repair Versus Replacement for Degenerative Disease done by McNeely et al. [61] showed that results of freedom from reoperation following MV repair were comparable to present study.

Freedom from Infective Endocarditis

None of the patients in our study group suffered from infective endocarditis during follow up period. Similar result had been noted in a study conducted by David TE et al. [59] who found freedom from infective endocarditis to be 99% in his study group.

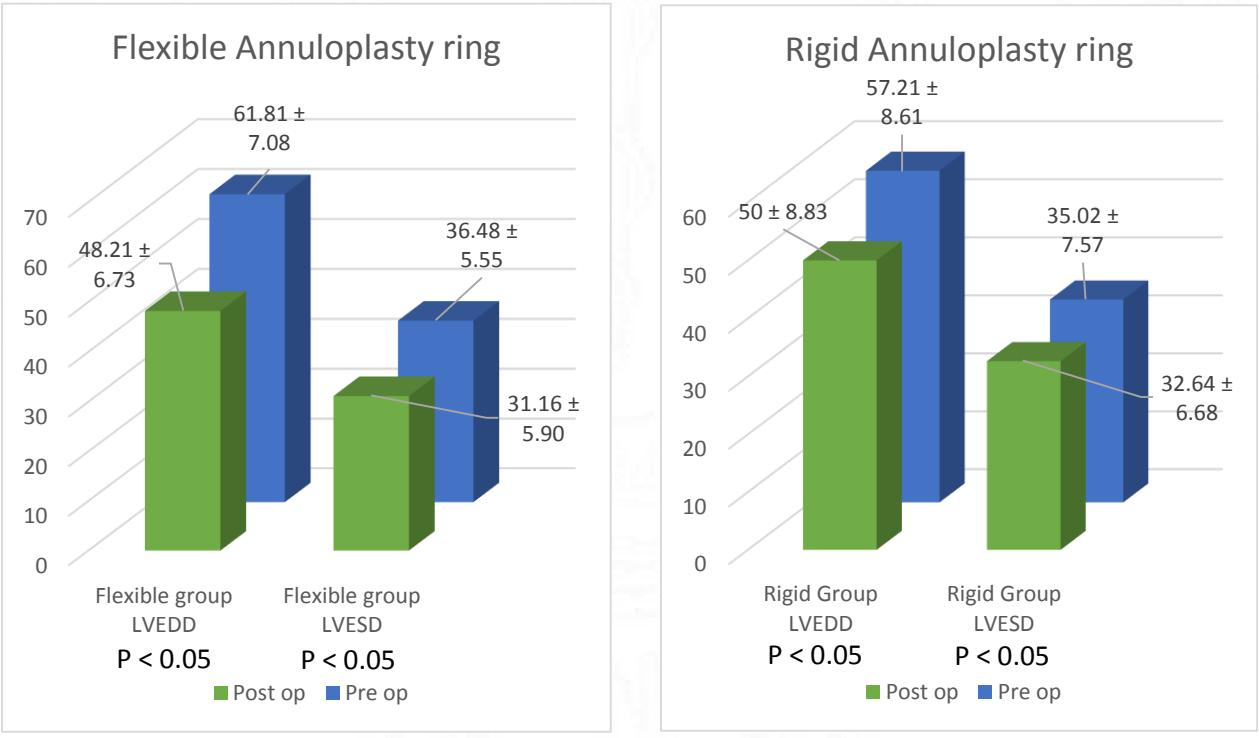
Freedom from CVA

One patient suffered from CVA, who was receiving Anti coagulation for atrial fibrillation during mean 5 year follow up period. Patient was managed medically and recovered with minimal residual defects. Freedom from Thromboembolic events was 99.3% during median follow up of 5 years. A study by Seeburger J et al. [62] showed Freedom from Thromboembolism of 97.6% during a 5 year study following MV repair.

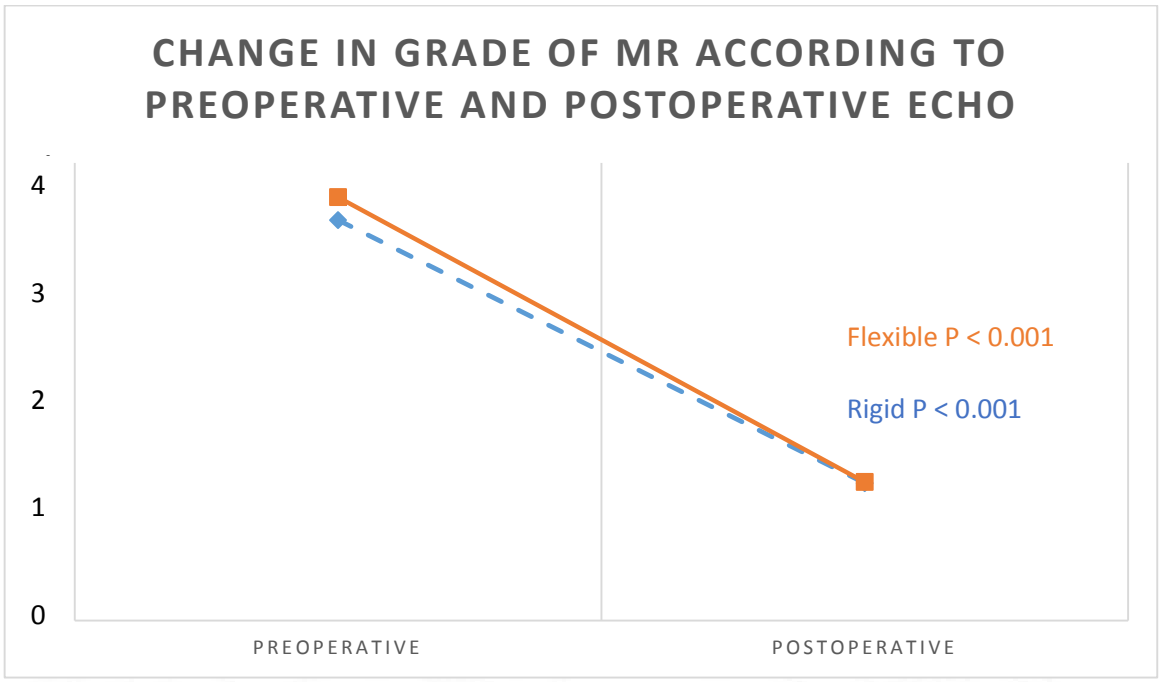
Choice of Annuloplasty Ring Size and Rigid or Flexible annuloplasty ring

Innovation of flexible annuloplasty rings by Dr. Carlos M. G. Duran for dynamic annulus, significantly improved the out of MV repair surgery [44]. Patients with regurgitant myxomatous mitral valves that underwent repair with a ring had a 3.6% recurrence rate, which contrasts with a recurrence rate of 15% for valves that underwent repair without a ring [45]. This indicated need for annuloplasty rings myxomatous MV disease.

Scientific Ring Sizing Strategy remains a Realistic Goal, where Ender and colleagues published a strategy in which the ring size was selected by superimposing computer-aided design models of annuloplasty rings onto live three-dimensional echocardiographic loops [63]. Their study showed preoperative ring sizing correlates well with intraoperatively measured ring sizes, but it does not allow for predicting the amount of postoperative coaptation. Similar results have been drawn by various studies in literature.



Graph 12: Comparison of pre-operative Left Ventricular dimensions to post-operative regressed Left Ventricular dimensions in Flexible and Rigid Prosthetic Annuloplasty ring groups

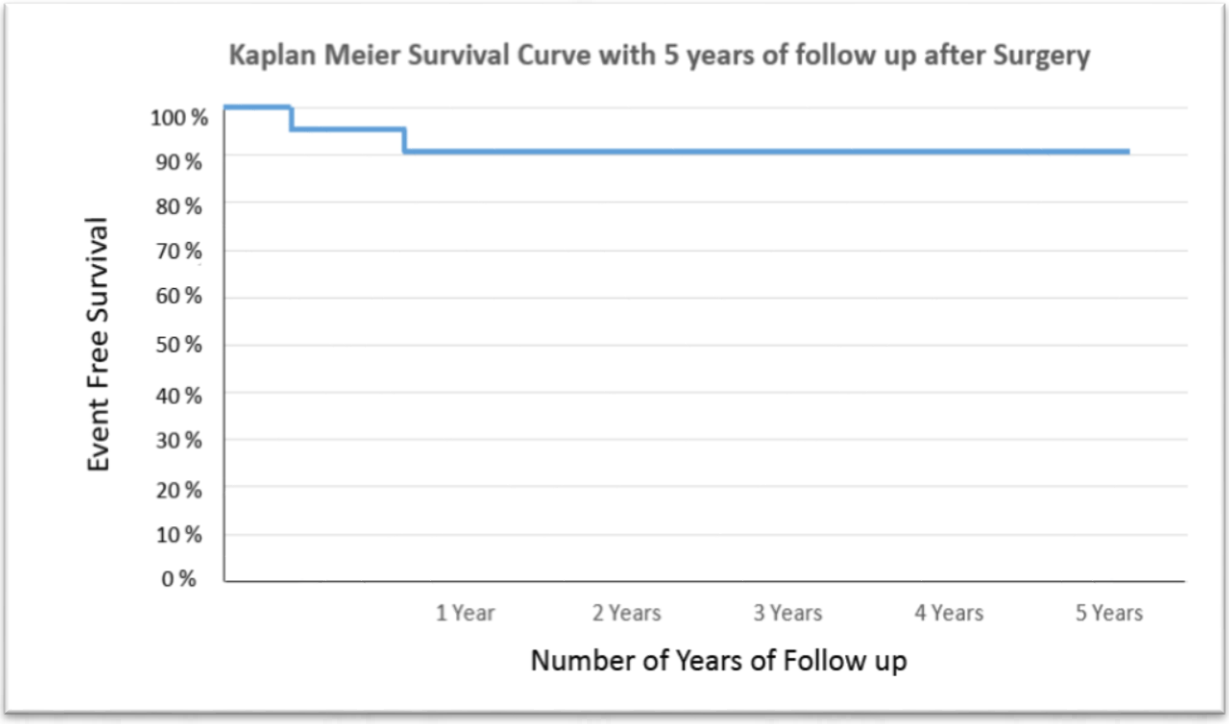


Graph 13: Change in grade of MR According to preoperative and postoperative ECHO in Rigid and Flexible ring groups

Recently surgeons have come up with Novel sizing technique for developing various custom made ring sizers [64]. Encouraging early results are seen, but are still need long term follow up of patients and evaluation. Pitsis A et al has developed a personalised mitral ring technique with promising long term results which is published recently [65], which is a newer technique relatively and yet to be available widely.

By this current study with a 5 year follow up, which has good long term results in aspect of Change in grade of MR according to preoperative and postoperative ECHO in Rigid and flexible ring groups ($p < 0.001$). Univariate analysis of pre-operative Left Ventricular dimensions to post-operative regressed Left Ventricular dimensions, where use of Rigid and flexible ring both have comparable results for ventricular remodeling ($p < 0.05$) in along with good current functional class of operated patients. We recommend for consideration of BSA during sizing of ring to prevent postoperative functional mitral stenosis or residual insufficiency.

Event free Survival



Graph 14: Kaplan Meier Survival Curve for Event free Survival after 5 years of Surgery

There has been no mortality recorded in present study. The overall survival rate following MV repair as documented in various other studies are similar to our study. In the 12 year study by Gillinov et al. [66] survivability was 95%. In study by Gaur et al. (58) was 96.4%, confirming that post-operative survival is satisfactory after MV repair. 2 patients underwent Redo Surgery with Mitral Valve Replacement for recurrence of Severe MR IV + after initial MV Repair. 1 patient suffered from CVA who was receiving Anti coagulation for atrial fibrillation during mean 5 year follow up period.

The current study is a single center experience regarding surgical repair of mitral valve. Our center is an apex center for cardiac disease with skills and excellence gained over 40 years. The outcome analysis shows excellent and promising results and our results substantiates with results over worldwide.

CONCLUSION

By this current study with a 5 year follow up, which has good long term results in aspect of Freedom from progression of Mitral regurgitation, Freedom from Re operation or complications. Mitral Valve repair is a procedure which gives long standing remedy for mitral regurgitation, if we follow the basic principles of durability of repair regardless of the type of annuloplasty. Burden of long term Anti coagulation is relieved in patients who underwent MV repair and with good regressed LV dimension in both prosthetic ring groups, We recommend MV repair for all degenerative mitral valve disease and consideration of BSA during sizing of ring to prevent postoperative functional mitral stenosis or residual insufficiency rather than type of ring.

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PROFORMA

Mitral Valve Repair – Single Centre experience with 5 year follow up study of operated patients.

Study Case No:
AGE: SEX:
Diagnosis:
Pre-operative symptoms and NYHA FC:

Pre-operative risk factors:

Pre-operative ECHO assessment:

- LA / LV size -
- Mitral valve -

- LV Function:
- Other Valves:
- PAH Status

Pre – Op Diagnosis:
Date of Surgery:
Intra operative findings:

Intra operative TEE assessment:

- LA / LV size -
- Mitral valve -

- LV Function:
- Other Valves:

Surgery:
Height: Weight: BSA:
MV repair details:
Annuloplasty details:

Post-operative NYHA FC:

Post-operative ECHO assessment:

- LA / LV size -
- Mitral valve -

- LV Function:
- Other Valves:
- PAH Status:

Symptoms and complaints on follow up:
Follow up NYHA FC:

- Patient subjective feeling
- Functional Class

New Clinical findings:

Follow up ECHO assessment:

- LA / LV size -
- Mitral valve -

- LV Function:
- Other Valves:
- PAH Status:

PLAGIARISM CERTIFICATE

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