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Comparison of Pericardial and Prosthetic Rings for Mitral Repair: Are Pericardial Rings Durable in the Mid- to Long-Term Follow Up?

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ABSTRACT

Background: While prosthetic rings are commonly used for mitral valve repairs, autologous pericardium is an alternative ring material that can be used in these procedures. In this report, we aim to present a comparison of two types of rings used for mitral repair.

Methods: Between January 2005 and January 2009, 107 patients who underwent mitral valve repair surgery were analyzed. Patients were divided into two groups, according to the type of ring that was used for mitral annular stabilization. Glutaraldehyde-treated pericardial rings were used for 31 patients (group 1), whereas prosthetic rings were used for 76 patients (group 2). Survival, freedom from reoperation, recurrent mitral regurgitation, and the effects of rheumatic mitral disease on these parameters were evaluated and compared for both groups.

Results: Follow-up time for our cohort was 4.24±0.4 years. There were four and seven late mortalities in groups 1 and 2, respectively, and five reoperations in each group. There was no significant difference between the groups, in terms of survival, freedom from reoperation, and recurrent mitral regurgitation (log-rank analyses for both groups were $P = 0.777$, $P = 0.346$, and $P = 0.781$, respectively). There was no significant difference in freedom from reoperation and recurrent mitral regurgitation for both groups, in terms of underlying rheumatic valvular disease and other types of pathology.

Conclusion: Pericardial ring annuloplasty shows to be a considerable alternative technique for mitral valve repair procedures in the mid- to long-term follow up. Rheumatic mitral valves had poor outcomes, when compared with other types of structural valvular pathologies in cases where pericardial rings were used in the repair procedure.

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INTRODUCTION

Annular dilatation is one of many causes of mitral regurgitation (MR) and also can be seen with other accompanying deteriorating factors causing MR. Therefore, mitral annular stabilization has been a critical consideration in mitral repair procedures [Galloway 1988; Carpentier 1971]. Several methods have been defined to ensure annular shape and stability. Among these methods, the most prominent and widely accepted approaches are prosthetic ring annuloplasties [Pitsis 2019; Hetzer 2014]. Despite the acknowledged advantages of prosthetic rings, they have the complication risks associated with prosthetic materials, such as ring dehiscence and hemolysis [Hetzer 2014; Miura 2020]. Additionally, high costs as well as matters regarding the supply of all sizes of rings can pose as a barrier for their use in the developing countries [Miura 2020].

On the other hand, as an alternative, annuloplasties also can be performed with autogenous pericardial tissue. The use of autogenous materials is focused on providing annular remodeling without the deterioration of the annular dynamic structure [Hetzer 2014; Borghetti 2000; Scrofani 1996]. In this study, the mid- to long-term results of mitral annuloplasties for isolated mitral valve regurgitation performed with autologous pericardium and prosthetic rings are compared.

METHODS

Patients: Between January 2005 and January 2009, 107 mitral valve repairs with annuloplasties were performed for isolated MR in our hospital. Follow-up duration for our cohort was 4.24±0.4 years. Maximum follow-up duration was 15.4 years. Degenerative, myxomatous and rheumatic mitral valve diseases that cause severe MR in all adult age groups were included. Patients operated on for concomitant cardiac pathologies, reoperations for cardiac lesions, endocarditis and tumors causing MR were excluded from the cohort. Glutaraldehyde-treated autologous pericardial rings were used for mitral repair in 31 patients (group 1), whereas prosthetic rings were used in 76 patients (group 2). Patients who underwent the edge-to-edge repair technique, which was performed only in the prosthetic ring group, were excluded to provide homogeneity between the

groups. Pre- and postoperative left ventricular end-diastolic (LVEDD) and end-systolic diameter (LVESD), left-atrial diameter (LA), ejection fraction (EF), pulmonary arterial pressure (PAP) and the degree of mitral (MR) and tricuspid regurgitation (TR) were recorded and analyzed with echocardiography.

Information regarding the structure of the valvular pathology was obtained from echocardiographic evaluations and operational logs. Perioperative data and echocardiographic evaluations of the patients were obtained retrospectively from the hospital archive system. The follow-up data of the patients for the mid- to long-term mortality and morbidity were obtained from the National Healthcare Registry. This study was approved by the Institutional Ethics and Review Board (IRB:28001928-604.01.01).

Surgical technique: When surgically feasible, mitral valve repair techniques are considered as the first choice of surgical treatment in mitral valve diseases [O'Gara 2017], as was the strategy in our hospital. Standard aortic and bi-caval cardiopulmonary bypass settings with moderate hypothermia were initiated for this procedure. Cardiac arrest was accomplished and sustained with intermittent cold blood cardioplegia and an aortic cross clamp. Pathology-oriented repair techniques were performed using mitral annuloplasty. A prosthetic ring or a glutaraldehyde-treated autologous pericardium strip were used for annular stabilization. St. Jude sizers were used to ensure appropriate sizing for both the prosthetic ring and the length of the strip. Both the ring and pericardial strip were stabilized via mattress stitches to the posterior annulus. Procedural steps for the pericardial ring are shown in Figure 1. After the repair procedure, mitral valves were tested via saline injections to confirm adequate valvular competence. Under appropriate conditions, a Cox/Maze III procedure with radiofrequency ablation was performed. After achieving a satisfactory result, the patients were weaned from bypass as by routine protocol. Prior to the removal of the cannulas, the mitral valvular competence was confirmed via transesophageal echocardiography.

Statistical analysis: SPSS Statistics 22.0.0.0 (IBM Inc., Armonk, NY) software was used for statistical analysis. Continuous data are presented as mean ± standard deviation. The degrees of mitral and tricuspid regurgitation were presented as medians and interquartile ranges. Categorical data are reported as absolute numbers with percentages. Differences between continuous data among groups were analyzed using independent sample t-tests and Mann Whitney U tests, while the Pearson chi-square test and Fisher's exact test were used to analyze categorical data. Statistical significance was set at $P < 0.05$. The Kaplan-Meier method was used for survival, freedom from reoperation and freedom from recurrent over-moderate mitral regurgitation analysis with a 95% confidence interval. This method also was used to compare the effect of rheumatic disease on freedom from reoperation and recurrent MR for each group.

RESULTS

Preoperative and operative data are presented in Table 1. There were no significant differences between the parameters of the two patient groups. Follow-up echocardiographic findings are presented in Table 2. There were no significant differences between the patient groups with regard to the postoperative echocardiographic parameters.

The Cox/Maze III procedure was performed for three patients with atrial fibrillation (AF) in group 2. Two of these patients had normal sinus rhythm, during the early postoperative period. There were no in-hospital early postoperative deaths in either group. There were four cardiac-related late deaths in group 1. One patient, who had AF postoperatively, died due to a massive stroke in his second postoperative year. The rest of the patients died due to heart failure 4, 10, and 15 years after the operation. Overall survival rates for group 1 at 1, 5, 10, and 15 years were 96.0%, 89.6%, 74.7%, and 74.7%, respectively. There were five conversions to mitral valve replacement in this group consisting of three patients with MR and two with mitral stenosis; reoperations were performed at 5 months, 3, 4, and 7 years after the initial operation. Four of these valves were rheumatic, and one was degenerative. A new onset of AF was observed in two patients. Freedom from reoperation rates for group 1 at 1, 5, 10, and 15 years after surgery were 96.7%, 86.5%, 79.3%, and 68.0%, respectively, and freedom from recurrent MR (over moderate) at 1, 5, 10, and 12 years after operation was 96.8%, 68.5%, 51.5%, and 0%, respectively.

There were seven late mortalities in group 2. Overall survival rates for this group at 1, 5, 10, and 12 years after operation were 98.5%, 84.9%, 70.8%, and 70.8%, respectively. Four patients died due to heart failure at 6 months, 1, 5, and 10 years postoperatively. Three patients died due to ICU-related complications, multiorgan failure and AF-related cerebrovascular events at 1, 2, and 4 years after the initial operation. Freedom from reoperation rates 1, 5, 10, and 12 years postoperatively were 98.4%, 90.2%, 83.7%, and 62.8%, respectively. Five patients had reoperations for mitral valve replacements at 8 months and 2, 4, 5, and 11 years postoperatively; four of these patients had MR while one had mitral stenosis. Two of the valves were rheumatic, two were degenerative, and one was myxomatous in structure. Freedom from moderate MR after the initial surgery at 1, 5, 10, and 12 years was 97.4%, 66.5%, 26.6%, and 26.6%, respectively. There were no significant differences between groups 1 and 2 in terms of survival, freedom from reoperation and recurrent MR, and log-rank analyses were $P = 0.777$, $P = 0.346$, and $P = 0.781$, respectively. (Figure 2) (Figure 3) (Figure 4) There was no statistically significant difference between rheumatic and other types of valves in terms of freedom from reoperation and recurrent MR. (Figure 5) No patient underwent a reoperation for another mitral repair procedure in either group after the initial surgery.

DISCUSSION

It is widely accepted that mitral ring annuloplasty is an essential step in mitral valve repair; however, the ideal type of ring to be used for annular stabilization still is a controversial subject [Miura 2020]. Some studies recommend the use of prosthetic rings for mitral valve repair as well as the use of

Table 1. Preoperative and operative patient demographics

	Group 1 (pericardial ring) (31pt)	Group 2 (prosthetic ring) (76pt)	*P* value
Preoperative data			
Age(years)	46.84±18.01	44.68±14.93	0.516
Sex (female)	17(54.9%)	46(60.5%)	0.142
Atrial fibrillation	5(16.1%)	12(15.7%)	1.000
Etiology			
Rheumatic	16 (51.6%)	38 (50%)	0.585
Degenerative	8 (25.8%)	26 (34.2%)	
Myxomatoid	7 (22.5%)	12 (15.7%)	
Follow up (years)	4.71±4.29	3.55±3.15	0.321
Echocardiographic data			
LVEDD	5.7±0.81	5.75±0.53	0.731
LVESD	3.81±0.88	3.94±0.75	0.45
EF	60.48±7.98	57.55±9.54	0.135
PAP	44.32±14.04	41.21±11.41	0.235
LA	5.97±0.94	5.99± 0.8	0.82
TR	2(1-3.5)	2(1-2)	0.881
Operative data			
Bypass time	65.9±20.31	65.41±20.76	0.823
Cross time	91.65±25.9	88.53±27.13	0.586
Technique of the mitral repair			
Quadrangular resection	14(45.1%)	37(48.6%)	
Anterior neochordae implantation	5(16.1%)	11(14.4%)	
Annuloplasty (only)	7(22.5%)	15(19.7%)	
Chordal intervention (shortening/transfer)	2(6.4%)	9(11.8%)	
Quadrangular resection+papillary splitting	2(6.4%)	2(2.6%)	
Posterior cleft repair	1(3.2%)	2(2.6%)	

Table 2.

	Group 1 (31pt) Early Postoperative	Group 2 (76pt) Early Postoperative	*P* value	Group 1 (pericardial ring) (30pt) Late Post-operative	Group 2 (prosthetic ring) (72pt) Late Post-operative	*P* value
LVEDD	5.1±0.67	5.19±0.72	0.592	5.01±0.62	4.98±0.7	0.691
LVESD	3.5±0.78	3.6±0.87	0.545	3.3±0.66	3.4±0.83	0.414
EF	56±8.9	52±12.4	0.163	59±7.81	55.2±9.2	0.56
PAP	35±10.2	33±8.9	1.000	31.7±11.8	31.8±10.7	0.754
LA	5.7±1.29	5.4±0.77	0.432	5.71±1.1	5.38±0.66	0.327
TR	1(1-2)	2(1-2)	0.487	1(1-2)	2(1-3)	0.820

pericardial rings [Hetzer 2014; Miura 2020; Fundarò 2007; Gillinov 2009; Topham 2008]. The durability of prosthetic rings is a major advantage in annular stabilization; however, they also are associated with high costs, sizing issues, and concerns regarding left ventricular (LV) outflow obstruction and LV dysfunction [Hetzer 2014]. The potential advantages of pericardial rings include preserved mitral annular function, lower effects on ventricular function, the absence of a prosthetic material and lower costs [Gillinov 2009]. In our hospital, both techniques were performed. We can speculate that the selection, regarding the type of ring used, can be attributed to the surgeon's own experience and preference. Furthermore, the disadvantages associated with prosthetic materials, especially issues related to the supply chain and the cost of the rings, were factors impacting the selection process.

The results of posterior valvular repairs for degenerative

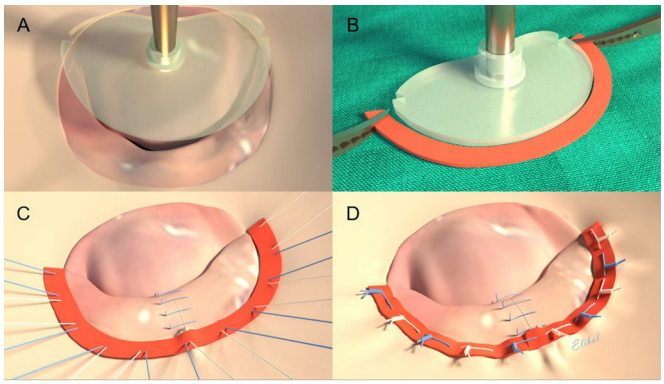

Figure 1.

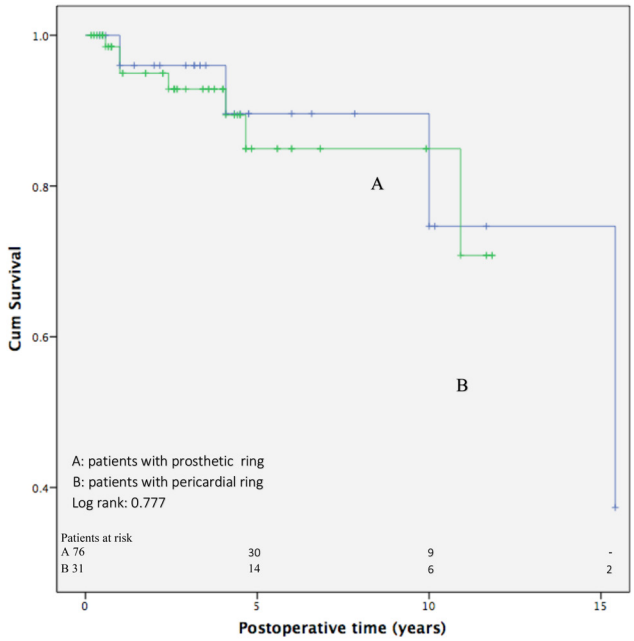

Figure 2. Kaplan Meier analysis showing survival curves for mitral repair with prosthetic and pericardial rings

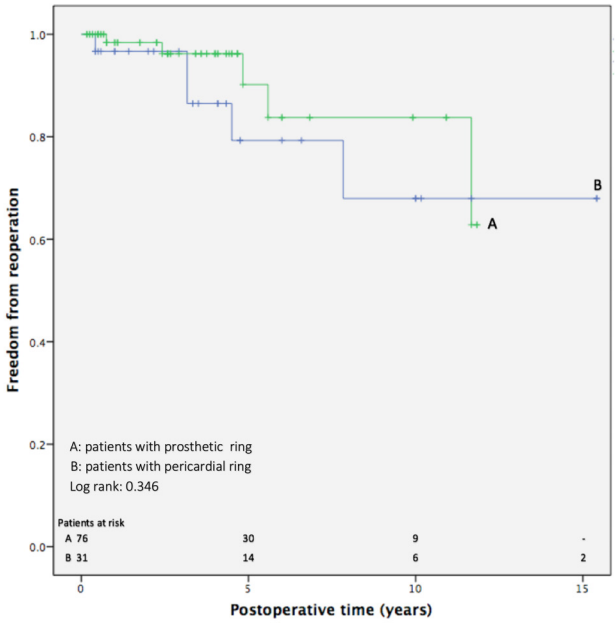

Figure 3. Kaplan Meier analysis showing freedom from reoperation curves for mitral repair with prosthetic and pericardial rings

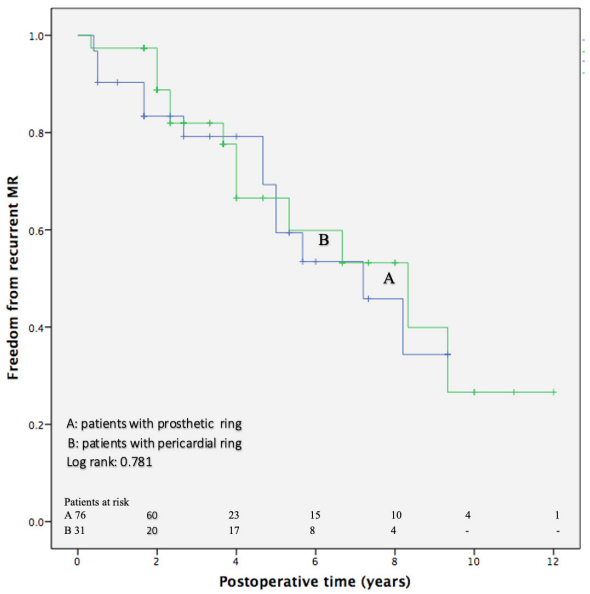

Figure 4. Kaplan Meier analysis showing freedom from recurrent MR curves for mitral repair with prosthetic and pericardial rings

mitral disease using prosthetic annuloplasty and other annuloplasty techniques were compared in a previous study. According to the results, posterior pericardial annuloplasties are not as durable as prosthetic annuloplasties for recurrent MR. However, freedom from reoperation and survival rates for both groups were similar [Gillinov 2009]. The results of this study are in agreement with our results when reoperation rates and survival rates for repairs with pericardial and prosthetic rings are compared. It was speculated that MR increases in the early period with the use of the pericardial ring; however, progress of MR was reduced during the late period in the same study [Gillinov 2009]. In our cohort, this phenomenon occurred in rheumatic valves repaired with pericardial ring annuloplasty.

Several studies suggest that glutaraldehyde-treated strip-shaped pericardial rings are reliable materials for annular stabilization [Hetzer 2014; Borghetti 2000; Topham 2008; Salvador 2013]. Miura et al. suggested that reinforcing the pericardial ring by twisting the pericardium in selected patients resulted in good outcomes. They reported their long-term follow up for isolated posterior mitral leaflet prolapse on degenerative valves and infective endocarditis. Their 15-year results can be attributed to their patient selection and the techniques they used, which were provided by reinforced

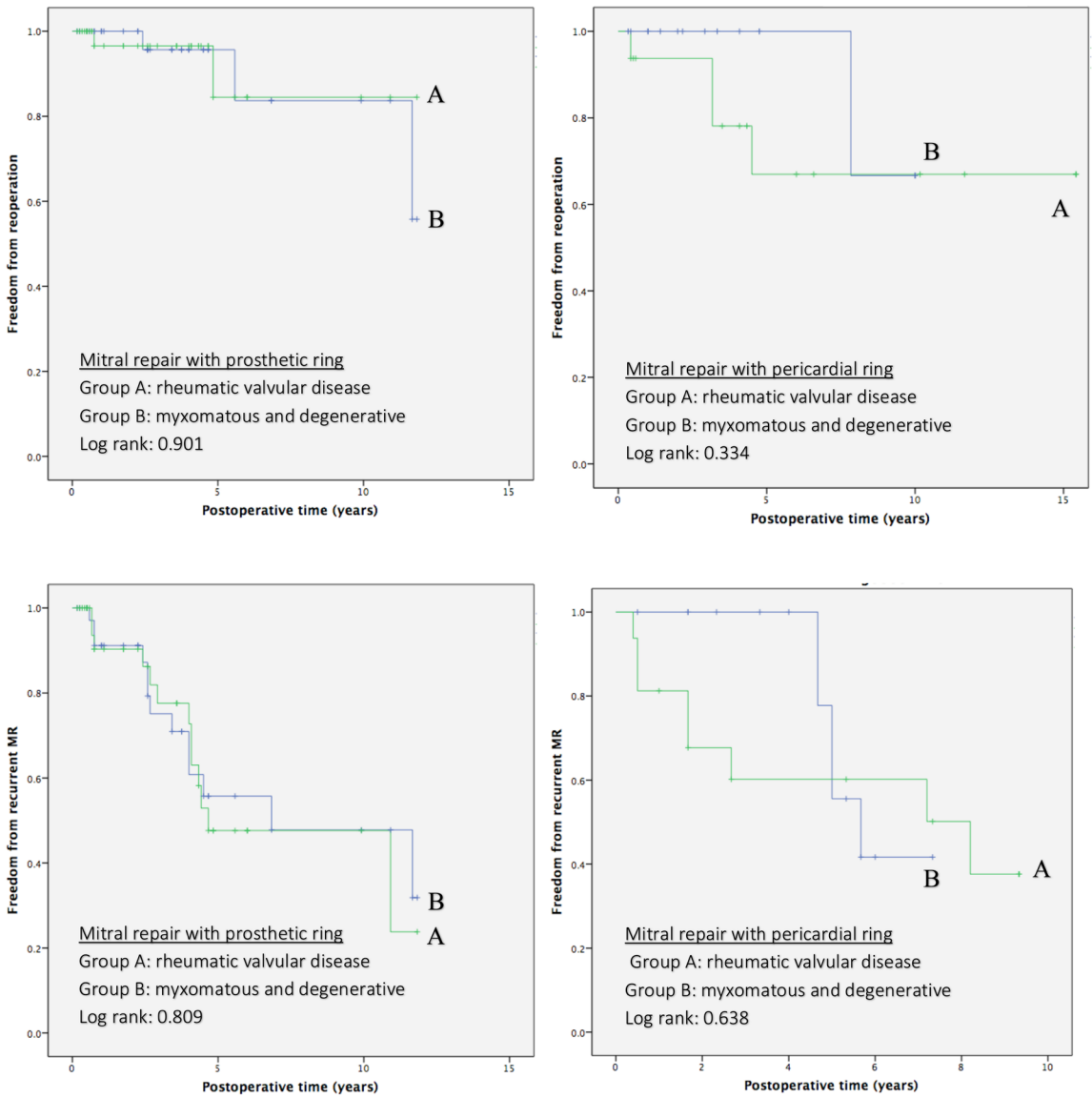

Figure 5. Kaplan Meier analyses showing freedom from reoperation and recurrent MR curves for mitral valvular pathology when prosthetic or pericardial rings were used

pericardial rings [Miura 2020]. Likewise, the non-rheumatic pathologies resulting from two pericardial annuloplasty techniques were defined and compared in an another study [Miura 2020]. Both techniques had remarkable results with specific indications, including a pediatric patient group. Further, David et al. found the biologic ring to be superior to the rigid ring, in terms of annular dynamics and LV function. The patients had ischemic mitral valves, endocarditis, and leaflet prolapses. The authors reported slightly better outcomes on survival and reoperation with pericardial annuloplasty [Topham 2008]. Poor results of pericardial annuloplasty with degenerative valve disease previously were reported; however, the authors stated that surgical limitations may have affected the results [Bevilacqua 2003]. None of the studies in which annuloplasty was performed with pericardium included patients with rheumatic mitral valve disease. The reason for the slightly poor outcomes of survival, reoperation and recurrent MR in our study is that the number of patients with rheumatic valve disease is higher when compared with the previous studies mentioned. These patients also had most of the reoperations and incidents of mortality.

The structure of the operated valve constitutes an important role in terms of mid- to long-term outcomes. Furthermore, it is known that the repair of rheumatic mitral valves results in poorer outcomes in comparison to repairs of other types of valvular structural deformities. The major problem with rheumatic valves is the progressive fibrosis and structural deformation of the valves, which contribute to the increased

likelihood of reoperation and valvular dysfunction in the postoperative follow up [Dougherty 2021]. However, recent studies have demonstrated better outcomes for rheumatic valve repairs, stating that they are "comparable" to those of other structural types [Dougherty 2021; Dillon 2015]. Given the fact that this study was conducted in a developing country, the majority of the valvular pathologies in our cohort were rheumatic. There was no significant difference between the groups, in terms of the structure of the valve. Even the effect of rheumatic valves on reoperation and recurrent MR rates were not statistically significant; the divergence of the Kaplan-Meier curves of patients with rheumatic valves with pericardial rings was conspicuous during the early postoperative period. It can be speculated that the deterioration of the mitral annulus caused by rheumatic disease affects mitral repairs with pericardial rings more than those with prosthetic rings. However, Kaplan-Meier curves of different pathologic mitral structures with the use of prosthetic rings unexpectedly overlap with statistically insignificant results, and this can be attributed to certain limitations of this study. In our hospital, most of the advanced rheumatic mitral valves are treated with mitral valve replacement. However, factors, including the need for lifetime anti-coagulant use, increased risk of rapid mitral valvular deterioration leading to a redo surgery following mitral repairs and the use of bioprosthetic valves are always a question mark in the decision-making process regarding the surgical strategy to be followed in these patients [Dillon 2015]. Furthermore, operation at a younger age and acceptable cardiac parameters (lower LVEDD and pulmonary artery pressures, normal EF, proper morphology) are influencing surgeons' preference of surgical technique in favor of a mitral repair approach. Moreover, Antunes et al. advocated that sub-optimal repair for those patients may be more acceptable in developing countries which was considered a time-saving strategy before mitral valve replacement [Dillon 2015].

Although it was accepted that annuloplasty is an incorporated method for annular stability and durability, an only-annuloplasty technique was performed in up to 17% of the patients in certain reports [Bevilacqua 2003; Coutinho 2017]. In our series, there is a considerable percentage of patients on whom an only-annuloplasty technique was performed mainly to treat annular dilatation. Considering the lower mean age of our cohort, an only annuloplasty operation may have been performed as a definitive repair strategy to avoid redo surgeries; however, this approach may also be responsible for the higher rates of recurrent MR in our results.

Atrial fibrillation is present in 30–50% of patients, who undergo mitral valve surgery [Coutinho 2017], and is also associated with the prognosis of the pathology [O'Gara 2017; Coutinho 2017]. In our cohort, 17 (15.8%) patients had AF, and two (18.1%) mortalities were related to AF. In our clinical practice, considering the need for anticoagulant use in AF patients, it may be speculated that surgical preference may have been inclined toward valve replacement in MR patients with AF. On the other hand, concomitant ablation surgery for AF has been recommended since 2010 in guidelines [Castellá 2017]. According to the 2016 ESC guidelines for the management of atrial fibrillation, Cox/Maze ablation surgery should be considered for patients who have undergone cardiac surgery (class IIa; level A) [Kirchhof 2016]. However, Coutinho et al. proposed the reconsideration of this statement and classified as a class I recommendation, due to the unfavorable effects of AF [Coutinho 2015]. However, the increased incidence of permanent pacemaker implantation after ablation surgery should be noted [Kirchhof 2016]. In our cohort, surgical ablation treatments were sporadically performed during the study time period.

Limitations: This study was a single-center retrospective study. Our hospital is a referral hospital that accepts patients from various districts of the country; hence, some data about the patients could not be obtained due to difficulties in patient follow up. The number of patients included in this cohort was small. The majority of our cohort included rheumatic mitral valves, which were prone to negative results. Rheumatic valve disease is a unique pathology that deserves attention regardless of the number of "comparable" results with repair that were reported. The non-homogeneous distribution of valve structures within the groups is one of the disadvantages of a retrospective study; however, statistical similarity between the groups was noted.

CONCLUSION

Pericardial ring annuloplasty can be an alternative method for mitral posterior annular stabilization and should be kept in the surgical armamentarium. The long-term results of annuloplasties with pericardial rings are comparable to those with prosthetic rings. Rheumatic valves must be viewed in consideration for their slightly poorer outcomes when pericardial rings are used, as opposed to other structural valvular pathologies.

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