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## *Durability of Mitral Valve Repair with Self-Made Annuloplasty Rings*

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### **Abstract**

**Objective :** To report the results of our self-made annuloplasty rings and to identify factors influencing the durability of mitral valve repair.

**Methods :** Between January 1991 and May 1999, 132 patients with mitral insufficiency underwent mitral valve repair with self-made annuloplasty rings. Mitral insufficiency was due to rheumatic disease in 78 patients, degenerative disease in 44 patients, endocarditis in 6 patients, and congenital heart disease in 4 patients. A total of 85 patients were in functional class III or IV preoperatively. Mid-term follow-up was available in 131 patients from 1 month to 8.1 years (average 2.9 years).

**Results :** Operative mortality was 0.8 per cent. At 5 years, survival and event-free survival rates were 92 and 82 per cent respectively. One hundred and fourteen patients (97%) were in functional class I, 3 patients (3%) were in class II. Echocardiography at follow-up showed satisfactory mitral valve function. Durability of repair was adversely affected by younger age, rheumatic heart disease, atrial fibrillation, associated diseases, and functional class.

**Conclusions :** Mid-term results of self-made annuloplasty rings are comparable to commercial ones. Durability was adversely affected by multiple factors.

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Mitral valve repair has been used with increasing frequency for surgical treatment of patients with mitral valve disease. Many kinds of annuloplasty rings and bands are being used.<sup>1-4</sup> This study describes our experience of mid-term results of mitral valve repair with self-made polytetrafluoroethylene (PTFE) annuloplasty rings and identifies factors influencing the durability of mitral valve repair.

### **PATIENTS AND METHODS**

Between January 1991 and May 1999, 132 patients with mitral valve insufficiency underwent repair with mitral annuloplasty. There were 59 males and 73 females, age ranged from 3 to 68 years (average 29 years). Criteria for mitral valve repair surgery in this study was significant mitral regurgitation with progres-

sive left ventricular dilatation. Exclusion criteria were calcified or severe fibrotic valves. Severe shortening and fusion of chordae and papillary muscles, prolapse, or destroyed leaflet which required resection more than one fourth of its length were also excluded. Informed consent was obtained from all patients before participation in this study. This study was approved by the Board of Institute of Cardiovascular Diseases, Rajavithi Hospital on January 3, 1991.

The causes of mitral regurgitation in this study were rheumatic heart disease in 78 patients (59.1%), degenerative disease in 44 patients (33.3%), and endocarditis in 6 patients (4.5%) and congenital heart disease in 4 patients (3.0%). All patients had significant mitral regurgitation. The associated lesions and operative findings were shown in Table 1. Eight patients (6.1%) were in functional class I, 39 (29.5%) in class II, 58 (43.9%) in class III, and 27 (20.5%) in class IV. Fifty-six patients (42.4%) were in sinus rhythm and 76 patients (57.6%) had atrial fibrillation.

All patients had echocardiograms before operation, 77 percent showed severe mitral regurgitation and 23 per cent moderate regurgitation with associated mitral stenosis.

### *The annuloplasty rings*

Our rings were constructed with 4-mm diameter PTFE tube and No. 1 stainless steel wire. A segment of approximately 11-cm long wire was placed inside the lumen of the 10-cm long PTFE tube. The ring was constructed on a cylinder of 3 cm in diameter. Both ends of the wire were then twisted together making a circular ring of 10 cm in circumference. In such a way this would be approximately 3 cm in diameter and 6.0-7.0 cm<sup>2</sup> in cross-sectional area. Both ends of the PTFE tube were joined and sewn together with silk. The ring could be reshaped manually into different shapes such as circular, ellipsoid, or asymmetrical shape. Because the framework of the ring was not rigid, its configuration changed during cardiac cycle. So, the ring was flexible. The cost of a ring was US\$ 150.

We used the same concepts of mitral valve repair described by Carpentier.<sup>1</sup> Rheumatic patients had more severe fibrotic valves and required more aggressive mobilization technique. The frequent surgical techniques employed for rheumatic heart disease were chordal and papillary muscle splitting for degenerative disease, leaflet resection and chordal shortening

plasty. Our annuloplasty ring was first shaped into shorter (4-cm) anterior portion and longer (6-cm) posterior portion, then implanted on mitral annulus accordingly with interrupted mattress sutures. The mitral competency was tested after repair by passing a 12-Fr cannula into the left ventricle through cardioplegic opening in the ascending aorta. Saline solution was injected to fill the left ventricle to test competency of the mitral valve. The shape of the ring was reformed in some ways, for example, change of the curvature, anterior-posterior distance to achieve the best competency. Associated lesions were also repaired.

All patients received warfarin for 6 weeks post-operatively. Patients with atrial fibrillation received long-term warfarin. Follow-up was complete in all patients who survived the operation from one month to 8.1 years, with a total of 380.0 patient-years. Transthoracic echocardiography was performed at one week, one year, and 5 years after the operation in all patients except those who had reoperations for mitral valve replacement. Chi-square and Student's t tests were used for statistical analysis of difference between preoperative and postoperative data characteristics. Survival analysis was evaluated by Kaplan-Meier method.<sup>5</sup>

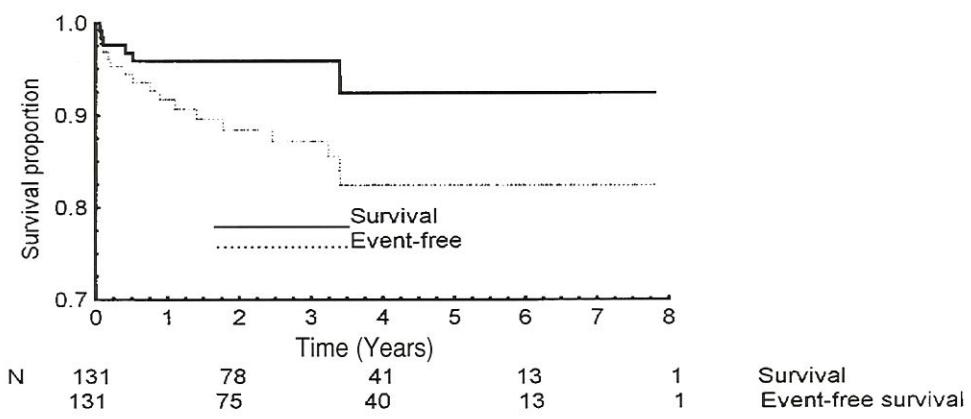
## RESULTS

There was hospital mortality in one patient (0.8%). One patient who required mitral valve replacement because of failure of repair due to restricted valve mobility was excluded. Late deaths occurred in 6 patients. The causes of death were cerebral hemorrhage due to warfarin overdose (1), cerebral embolism (1),

**Table 1** Operative findings and associated lesions (N=132).

Variable	Number	Percent
Annular dilatation	126	95.5
Commissural or chordal fusion	59	44.7
Prolapse	51	38.6
Chordal elongation	36	27.3
Chordal rupture	27	20.5
Tricuspid regurgitation	55	41.7
Aortic regurgitation	33	25.0
Atrial septal defect	13	9.8

*N* = number of patients.



**N=number at risk.**

**Fig. 1** Survival and event-free survival after annuloplasty.

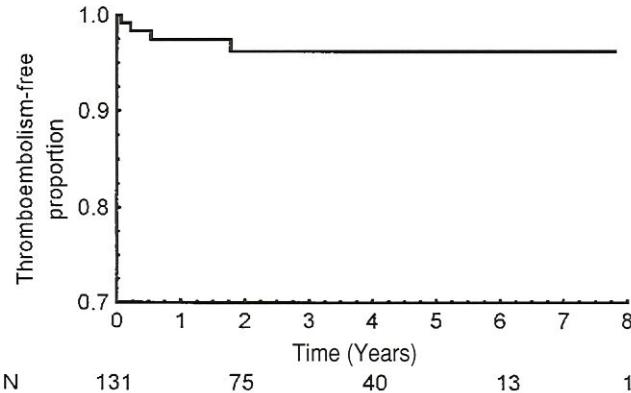
endocarditis (1), pneumonia (1), and unknown (3). Survival and event-free survival at 5 years were 92 and 82 per cent (operative mortality included) respectively (Figure 1). There were 4 thromboembolic events in 4 patients for an embolic rate of 1.1 per cent per patient-year. All thromboembolic events occurred in rheumatic patients who had atrial fibrillation. Freedom from thromboembolic events at 5 years was 96 per cent (Figure 2).

Mitral valve replacement was necessary in 6 patients, 3 patients (2.3%) required reoperation within one year. Five of these patients had rheumatic heart disease and the other had degenerative disease. The causes of reoperation were incomplete repair (2), progressive disease (2), ruptured chordae (1), and ring dehiscence (1). Freedom from reoperation was 92 per cent at 5 years. The reoperation rate was 1.6 per cent per patient-year. Durability of repair was adversely affected by rheumatic heart disease (Figure 3), younger age (Figure 4), atrial fibrillation (Figure 5), associated diseases (Figure 6), and patients' functional class (Figure 7).

The patients' functional class was significantly improved after operation. One hundred and twenty-eight patients (97%) were in class I and 3 patients were in class II ( $p<0.01$ ). Results of echo-cardiography were shown in Table 2 and Figure 8. No systolic anterior motion of the mitral valve was observed.

## DISCUSSION

The function of the annuloplasty ring is to restore dilated mitral annulus. In this study we tried to evaluate

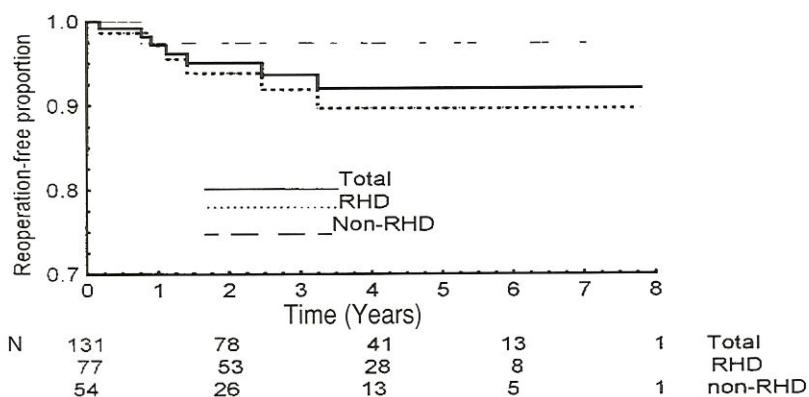


**N=number at risk.**

**Fig. 2** Thromboembolism-free survival.

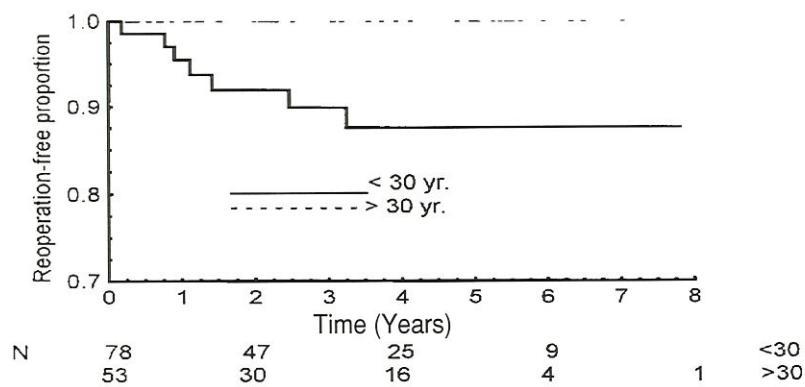
our self-made PTFE ring. We did not construct the ring according to the length of anterior part of mitral annulus. The diameter of our self-made annuloplasty ring was fixed at 30 mm in the present series based on our experience of mitral valve replacement. The follow-up echocardiography in our patients had demonstrated that the orifice was quite adequate. One advantage of this ring was that it was reshaping because its shape could be adjusted manually to achieve the best valve competency during operation. In our experience, adjustment of ellipsoid shape of the ring gave the best competency. Postoperative echocardiography showed good results of the repair and mitral annulus was restored to normal size and shape.

The predictability of success of the technique was demonstrated by the low incidence of early reoperation (2.3% at one year). Prosthetic ring dehiscence was seen in one patient. Some reports on the use of



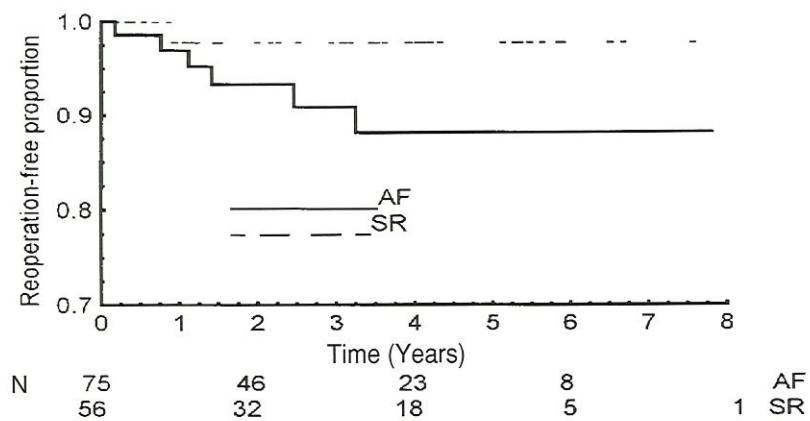
**N** = number at risk, **RHD** = rheumatic heart disease.

Fig. 3 Reoperation-free survival in rheumatic and non-rheumatic heart disease.



**N** = number at risk, **<30** = <30 years of age, **>30** = >30 years of age.

Fig. 4 Reoperation-free survival in different age groups.



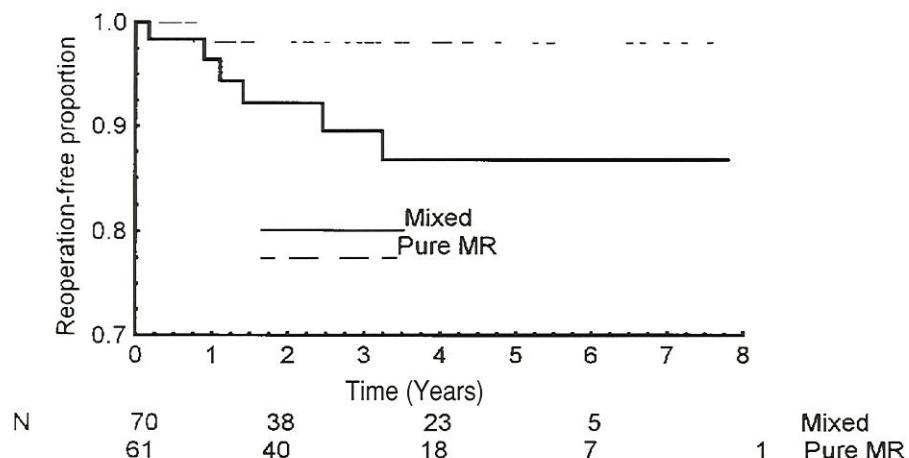
**N** = number at risk, **AF** = atrial fibrillation, **SR** = sinus rhythm.

Fig. 5 Reoperation-free survival in different rhythm.

annuloplasty rings showed the incidence of ring dehiscence ranging from negligible to 2.88 percent.<sup>2,3,6,7</sup>

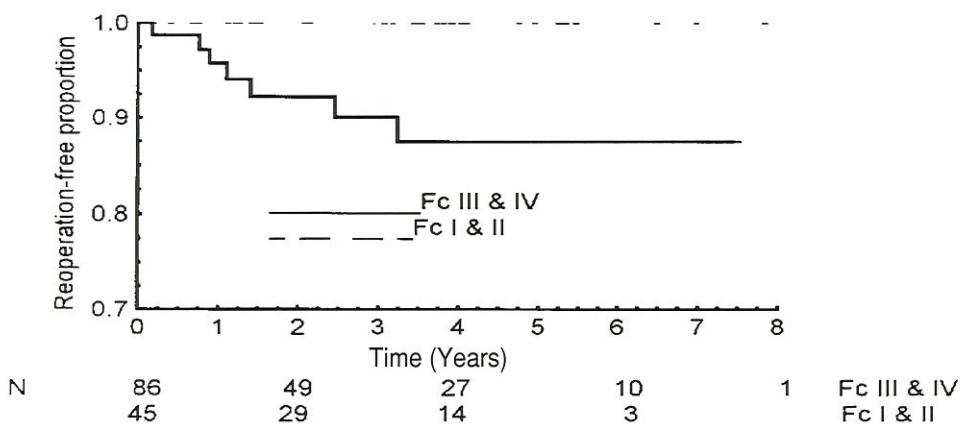
Patients' survival in this study was 92 per cent at 5 years which was comparable to other series using

commercial rings.<sup>1-4,6,7</sup> The incidence of reoperation was 1.6 per cent per patient-year with 92 per cent freedom from reoperation at 5 years. Most reoperation were performed in the rheumatic patients because the



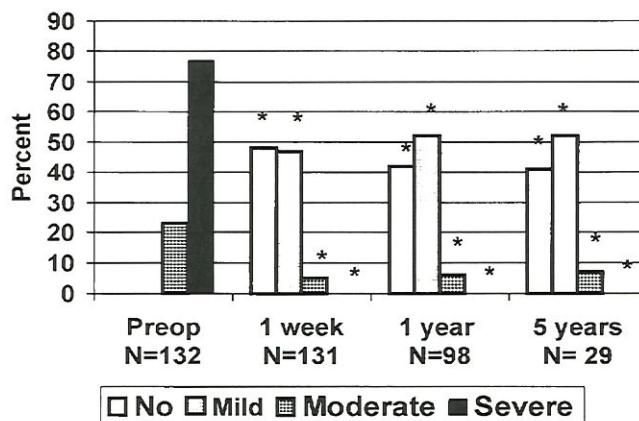
**N** = number at risk, **Mixed** = with associated diseases, **MR** = mitral regurgitation.

Fig. 6 Reoperation-free survival with or without associated diseases.



**N** = number at risk, **Fc** = functional class.

Fig. 7 Reoperation-free survival and patients' functional class.



\*p<0.01 versus preoperative measurement; **N** = number of patients; **Preop** = before operation; **1 week, 1 year, and 5 years** = time after operation.

Fig. 8 Echocardiography showed marked decrease of mitral regurgitation after repair.

valves were more fibrotic and the progressive destruction of rheumatic process. In our rheumatic patients, we found that there was an increasing degree of regurgitation during the follow-up. The other factors that adversely affected durability of repair were younger age, atrial fibrillation, associated diseases, and patients functional class. This study also confirms other reports that the patients with degenerative disease have a more favorable outcome.<sup>2,6,8</sup>

The incidence of thromboembolic complications in this study was 1.1 per cent per patient-year. Some reports showed thromboembolic rates of 0.6 to 2.52 per cent per patient-year.<sup>1,9</sup> Therefore, thromboembolism may not differently relate to this type of rings. Risk factor for thromboembolism is atrial fibrillation, so the patient who has risk factor should continue to

**Table 2** Echocardiographic Data.

Variable	Preop N = 132	Postop		
		1 week N = 131	1 year N = 98	5-year N = 29
EDV (ml)	292 ± 148	176 ± 103*	174 ± 99*	188 ± 84*
ESV (ml)	97 ± 61	92 ± 71	69 ± 57*	80 ± 43
EF (%)	67 ± 10	49 ± 16*	62 ± 12*	59 ± 14*
MVA-p (mm <sup>2</sup> )	363 ± 170	282 ± 104*	271 ± 96*	234 ± 99*
MVA-d (mm <sup>2</sup> )	243 ± 96	242 ± 66	200 ± 57*	195 ± 82*
MPG (mmHg)	8.7 ± 5.5	4.5 ± 1.7*	6.2 ± 2.8*	5.9 ± 1.8*

**a**Data are means ± standard deviation. \*p<0.01 versus preoperative measurement. EDV = end diastolic volume; EF = ejection fraction; ESV = end systolic volume; MPG = mean pressure gradient across mitral valve; MVA-d = mitral valve area (Doppler); MVA-p = mitral valve area (planimetry); N = number of patients; Postop = postoperative measurement; Preop = preoperative measurement.

receive anticoagulant.

Data from this study show that our self-made annuloplasty ring is inexpensive and can give excellent outcome comparable to other commercially available rings. The technique is reproducible and this ring is an alternative for using other commercial rings.

The limitation of this study is that we could not demonstrate the flexibility of our ring due to the lack of multiplane transesophageal echocardiography in our institute.

## CONCLUSION

This study shows the good mid-term results of our self-made annuloplasty ring. The main function of the ring is to restore dilated mitral annulus. It can be made very easily and it is cost saving. Durability of repair was adversely affected by younger age, rheumatic heart disease, atrial fibrillation, associated diseases, and patients' functional class. Long-term follow-up is required to confirm the stability of this self-made annuloplasty ring.

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