







■ Research Article

Correction of posterior mitral leaflet prolapse with Fundaro annuloplasty: Can suture annuloplasty techniques be helpful for surgeon?

Posteriyor mitral liflet prolapsusunun Fundaro anüloplasti ile onarımı: Sütür anüloplasti teknikleri cerraha yardımcı olabilir mi?

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Abstract

Aim: Fundaro annuloplasty is a posterior leaflet repair technique developed for asymmetric tethering of mitral leaflets due to inferior myocardial infarction. ". In our study, we aimed to share our the operative and mid-term results of the fundaro annuloplasty technique.

Material and Methods: 30 patients who underwent Fundaro annuloplasty for type 3b mitral regurgitation were included in the study. Fundaro annuloplasty with CABG was performed in 20 patients from this patient group, the remaining 10 patients underwent combined procedures. During the flollow-ups of the patients, physical examination, electrocardiography and transthoracic echocardiography were performed.

Results: The mean follow-up period of the patients included in the study was 35.8±20.3 months (min:1 max:59). According to the TEE datas performed intraoperatively, MR was not detected in 24 (80%) patients. The mean postoperative follow-up period of the patients was 35.8±20.3 months. During the follow-up period, recurrent MR was not observed in 23 (76.7%) patients. Mortality developed in 2 (6.7%) patients in the early postoperative period. Significant improvement was observed in their functional capacities(p<0.001). Improvements in mean left ventricular end-diastolic diameter, left ventricular end-systolic diameter, left atrial diameter, and pulmonary artery pressure were found to be statistically significant when compared with preoperative values (p=0.001, p=0.001, p=0.007 and p=0.001, respectively).

Conclusion: Fundaro annuloplasty is an advantageous because it can be performed in shorter XCL time. Low recurrence rate after repair and positive effects on ventricular remodeling can be achieved with this technique in patient with mitral valve insufficiency due to ischemia.

Keywords: mitral valve; ischemic heart disease; fundaro annuloplasty

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Öz

Amaç: Fundaro anuloplasti, inferior miyokard enfarktüsü nedeniyle oluşan mitral yetmezlikte lifletlerin asimetrik bağlanması için geliştirilmiş bir posteriyor liflet onarım tekniğidir. Çalışmamızda fundaro anuloplasti tekniğinin operatif ve orta dönem sonuçlarımızı paylaşmayı amaçladık.

Gereç ve Yöntemler: Tip 3b mitral yetersizliği nedeniyle Fundaro anuloplasti uygulanan 30 hasta çalışmaya dahil edildi. Bu hasta grubundan 20 hastaya KABG ile birlikte Fundaro anuloplasti uygulandı, geri kalan 10 hastaya kombine işlemler uygulandı. Hastaların takiplerinde fizik muayene, elektrokardiyografi ve transtorasik ekokardiyografi yapıldı.

Bulgular: Çalışmaya alınan hastaların ortalama takip süresi $35,8 \pm 20,3$ aydı (min:1 max:59). İntraoperatif yapılan TEE verilerine göre 24 (%80) hastada MY saptanmadı. Hastaların ameliyat sonrası ortalama takip süresi $35,8 \pm 20,3$ aydı. İzlemde 23 (%76,7) hastada tekrarlayan MY izlenmedi. Postoperatif erken dönemde 2 (%6,7) hastada mortalite gelişti. Fonksiyonel kapasitelerinde anlamlı iyileşme gözlemlendi ($p < 0.001$). Ortalama sol ventrikül diyastol sonu çapı, sol ventrikül sistol sonu çapı, sol atriyum çapı ve pulmoner arter basıncındaki düzelmeler ameliyat öncesi değerlere göre istatistiksel olarak anlamlı bulundu ($p = 0,001$, $p = 0,001$, $p = 0,007$ ve $p = 0.001$, sırasıyla).

Sonuç: Fundaro anuloplasti daha kısa XCL süresinde yapılabilmesi nedeniyle avantajlıdır. İskemiye bağlı mitral kapak yetmezliği olan hastalarda bu teknik ile onarım sonrası düşük nüks oranı ve ventriküler yeniden şekillenme üzerinde olumlu etkiler elde edilebilmektedir.

Anahtar Kelimeler: mitral kapak; iskemik kalp hastalığı; fundaro anuloplasti

Introduction

Myocardial infarction due to coronary artery disease may lead to a number of mechanical complications. Mitral regurgitation is also one of them. The incidence of ischemic mitral regurgitation in patients undergoing coronary angiography after myocardial infarction (MI) varies between 10.9 and 19.4%. Ischemic mitral regurgitation (IMF) was detected in 4-5% of patients who underwent coronary artery bypass (CABG) surgery. (1-3).

This coexistence increases mortality and morbidity and the treatment of this patient group is one of the most discussed topics in today's cardiac surgery practice. Chronic IMF is a functional disorder due to postinfarct ventricular remodeling. Among the pathophysiological mechanisms, apical displacement of the posterior papillary muscle due to infarction and global ventricular dilatation are seen. As a result, tethering occurs to both leaflets.

Prosthetic ring annuloplasty is considered the gold standard technique for mitral valve repair, but it has been associated with some drawbacks. Suture annuloplasty is less expensive and may have some physiopathologic advantages. Fundaro annuloplasty is a posterior leaflet repair technique developed for asymmetric tethering of mitral leaflets due to inferior myocardial infarction. The technique includes partial detachment of the posterior leaflet from the mitral annulus, annular plication, and posterior cusp plasty. It aims to eliminate the functional problem at the valvular level caused by the LV

lesion. Moreover, It can restore annular geometry by bringing the anteroposterior and intercommissural distances to a near-normal ratio. On the other hand, plication to the annulus reduces the posterior annulus diameter and repositions the tension in the mitral valve a little more anteriorly. The posterior leaflet widens in the anteroposterior axis and narrows in the intercommissural axis, thus providing better coaptation of the segment adjacent to the annular plication (4).

Although there have been many studies on the results of mitral valve repair techniques, there is no publication about the results of "Fundaro Annuloplasty". In our study, we aimed to share our the operative and mid-term results of the fundaro annuloplasty technique.

Material and Methods

30 patients who underwent Fundaro annuloplasty for type 3b mitral regurgitation at the Cardiovascular Surgery Clinic of Turkey Yüksek İhtisas Training and Research Hospital between August 2007 and August 2013 were included in the study. While Fundaro annuloplasty with CABG was performed in 20 patients from this patient group due to CAD and MR, the remaining 10 patients underwent combined procedures (ascending aorta, mitral-tricuspid-aortic valve surgeries, etc.). All surgeries were performed by the same surgical team, data of the patients were found from the hospital archive and preoperative demographic, clinical and operative data were accessed and recorded. The patients were followed for an average of 35.8 ± 20.3 months.

During the follow-ups of the patients, physical examination, electrocardiography and transthoracic echocardiography were performed. Postoperative severe mitral regurgitation, reoperation and mortality at any time were considered as the Primary Endpoint. Mortality during the first 30-day period after surgery was defined as early mortality and later ones defined as post-operative late mortality.

Surgical Technique

After general anesthesia, transesophageal echocardiography probe was placed in the patients for routine intraoperative evaluations. The operation was performed under CPB with bicaval cannulation following median sternotomy. Cardiac arrest were achieved with antegrade and retrograde cold blood cardioplegia routinely.

Mitral valve intervention was performed via left atriotomy at the Sondergaard plan in 27 (90%) patients and transseptal approach were preferred in 3 (10%) patients. Fixation sutures were placed on both commissures to provide a good surgical exposure. Mitral valve was examined with surgical hooks. Reactive endocardial thickening zone (candle flame appearance) due to the jet of regurgitant volume into the left atrium was tried to be determined. Posterior annular dilatation was seen. The tense portion of the posterior leaflet was separated from the mitral annulus with the help of an incision. Secondary chordas were transected to ensure posterior leaflet mobility. The separated posterior annulus part was plicated in the vertical plane with individual sutures. The remaining defect on the posterior leaflet was closed with a continuous suture technique. The plicated annulus was reinforced with flexible ring in 17 (56.7%) patients, rigid ring in 6 (20%) patients, and Teflon strip in 7 (23.3%) patients. After the procedures, saline test was performed to check the coaptation and then left atrium was closed with continuous prolene sutures. Warm blood cardioplegia was given and the cross-clamp was removed. Anticoagulation was neutralized with protamine sulfate at a ratio of 1:1 and cardiopulmonary bypass was terminated. TEE was performed in patients who have weaned from CPB. While MR was not detected in 24 (80%) patients, mild MR was detected in 6 (20%) patients. Following the bleeding control, 36 French drains and one pace wire were placed and the median sternotomy was closed with 4 figure of eight wires. After the closure of the skin and subcutaneous tissues, the operation was finalized and the patients were followed up in the intensive care unit.

Statistical Analysis

Statistical analysis was performed using SPSS v 20.0 (SPSS Inc., Chicago, IL, USA) package program. Continuous variables were

expressed as mean±standard deviation. Categorical variables were given as frequency percentages. Statistical differences between patients in the intervention and control groups were investigated with the t-test for continuous variables and the Mann-Whitney U test. Categorical data were evaluated with the chi-square test. A P value less than 0.05 was considered statistically significant.

Results

The mean follow-up period of the patients included in the study was 35.8±20.3 months (min:1 max:59). Demographic characteristics and preoperative echocardiographic data of these patients are presented in Table 1.

Table 1. Demographic characteristics and preoperative echocardiographic data of these patients are presented

Patient count(n)	30
Follow-up time(month)	35.8±20.3 (min:1 max:59)
Age	55.5±16.0 (min:15 max:84)
Sex(male)	16(%53.3)
NYHA classification	
I	3(%10)
II	22(%73.3)
III	3(%10)
IV	2(%6.7)
BMI(kg/m ²)	25.2±8.2
Hypertension	12(%40)
Diabetes Mellitus	5(%16.7)
Smoker	10(%33.3)
COPD	14(%46.7)
CVA	2(%6.7)
MI	4(%13.3)
Chronic Renal Insufficiency	3(%10)
Re-operation	-
ECG	
Sinus rythm	27(%90)
Atrial Fibrillation	3(%10)
AV block-Pace	0
Mitral Insufficiency	
None	0
Mild	0
Moderate	4(%13.3)
Severe	26(%86.7)
EF(%)	46.7±11.7 (min: 28 max:65)
LVEDD(cm)	5.77±0.69
LVESD(cm)	4.37±0.69
PAP(mmHg)	43±11.8
LA diameter(cm)	4.9±1

NHYA:Newyork Heart Assosiation, BMI: Body Mass Index, COPD:Chronic Obstructive Pulmonary Disease, CVO: Cerebrovascular Accident, MI: myocardial infarction, ECG: Electrocardiogram, EF:Ejection fraction, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, PAP:Pulmonary artery pressure, LA:Left atrial

In addition to fundaro annuloplasty, coronary bypass surgery in 20 (66.7%) patients, aortic valve surgery in 4 (13.3%) patients, ascending aortic surgery in 1 (3.3%) patient, tricuspid valve surgery in 6 (20%) patients, atrial valve surgery in 1 (3.3%) patient septal defect repair, left ventricular aneurysm repair in 3 (10%) patients were performed. The mean cross-clamp duration was 106.7±28.7 minutes, and the cardiopulmonary bypass duration was 142.1±28.6 minutes. The mean ring size of used in the patients after Fundaro annuloplasty was 29.09±1.9. Operative datas are presented in table 2.

Table 2. Operative datas

Combined Intervention	Coronary artery bypass	20(%66.7)
	Aortic valve surgery	4(%13.3)
	Ascending aorta surgery	6(%20)
	Tricuspid valve surgery	11(%36.7)
	Atrial septal defect surgery	3(%10)
Left Atrial Approach	Left atrial plication	3(%10)
	Sondergaard Plane	27(%90)
Cross-Clamp Time(min)	TSA	3(%10)
		106.7±28.7
Cardiopulmonary Bypass Time(min)		142±28.6
Annuloplasty Type		
Flexible Ring		17(%56.7)
Rigid Ring		6(%20)
Teflon stripe		7(%23.3)
No Annuloplasty		0
Median Ring Size		29.09±1.9(26-33)

TSA:Transseptal Approach

According to the TEE datas performed intraoperatively, MR was not detected in 24 (80%) patients, while mild MR was observed in 6 (20%) patients. Moreover, there was no need for intraoperative MVR since no patients were found to have moderate or severe MR. There was no intraoperative mortality. In the postoperative period, 10 (33.3%) patients needed inotrope support and 1 (3.3%) needed intra-aortic balloon pump during intensive care follow-up. The patients were intubated for an average of 17.4±9.7 hours, the follow-up duration in the intensive care unit was 3.0±2.1 days, and the hospital stay was 10.2±4.3 days. The average drainage of the patients was 740±479.8 ml, and 1 (3.3%) patient underwent reoperation due to bleeding. While no neurological

complication was observed in any patient in the postoperative period, ARF requiring dialysis was developed in 1 (3.3%) patient, pneumonia was seen in 1 (3.3%) patient, and GIS complication was occurred in 1 (3.3%) patient.

The mean postoperative follow-up period of the patients was 35.8±20.3 months (min:1 max:59). During the follow-up period, recurrent MR was not observed in 23 (76.7%) patients, while mild MR was observed in 1 (3.3%) patient. Re-repair was performed in 1 (3.3%) patient due to severe MR and MVR was performed in 1 (3.3%) patient. Mortality developed in 2 (6.7%) patients in the early postoperative period. While the first mortality was due to respiratory failure after aspiration on the 4th postoperative day, Sepsis secondary to mediastinitis on the 25th postoperative day is the cause of mortality of the other patient. Late mortality was observed in 2 (6.7%) patients during the postoperative follow-ups. The first of the late mortality was sudden cardiac death at 12 months and the second was due to heart failure at 48 months. Endocarditis, thromboembolism and hemolysis were not observed in any of the patients during the follow-up period.

When the preoperative and postoperative variables of the patients were compared, a statistically significant improvement was observed in their functional capacities according to the NYHA classification (p<0.001). In addition, the mitral regurgitation degree of the patients decreased from 3.1±0.5 to 1.07±0.8, which was also statistically significant (p<0.001). According to the postoperative ECHO datas, the mean ejection fraction increased to 48.5±11.3. However, this change was not statistically significant (p=0.46). On the other hand, improvements in mean left ventricular end-diastolic diameter, left ventricular end-systolic diameter, left atrial diameter, and pulmonary artery pressure were found to be statistically significant when compared with preoperative values (p=0.001, p=0.001, p=0.007 and p=0.001, respectively).

Discussion

Although the results of mitral valve repair are good in all etiologies of mitral regurgitation, surgical mortality in ischemic MR is higher. In addition, the long-term outcomes are less satisfactory and the recurrence rate of MR is higher after valve repair (5). In previous studies, preoperatively increased PLA (posterior leaflet angle) and ALA (anterior leaflet angle) values were found to be important in mid-term recurrence of MR in patients, and it was reported that mitral anterior tethering and posterior tethering determined by these values are independent predictors of recurrent MR(6).

Tethering is often seen in the posterior leaflet. While this causes an asymmetric and restricted leaflet movement in systole, a corresponding pseudoprolapsus is seen in the anterior leaflet. Although it varies, the posterior papillary muscle is often non-atrophied and displaced towards the apex due to segmental wall motion disorder or dyskinesia/akinesia (7-8). The reason why the repair results in type 3b mitral regurgitation are not satisfactory is due to this complex pathology and often co-existing serious diseases in these patients. However, it should not be forgotten that the experience and ability of the surgeon is an important determinant in the results of the operation.

Performing surgical techniques to restore the LV geometry, which will be done carefully and effectively to eliminate the functional IMR is important for the success of the repair. For his reason, it is necessary to narrow and fix the mitral annulus in the anteroposterior axis with annular ring. In addition, there is evidence that patients will benefit more from valve repair performed with CABG in the presence of significant myocardial viability in ischemic mitral regurgitation due to CAD. Many studies have also shown that severe ischemic MR in this disease group usually does not improve with revascularization alone (9-11).

While rigid rings are recommended for annuloplasty in ischemic MR patients, in this study group; Flexible, rigid rings or teflon felt strip are used according to the availability. It is known that flexible rings become rigid after a certain time (12).

In their study involving 482 patients Gillinov and his colleagues reported that in patients with ischemic mitral regurgitation mitral repair is more beneficial compared to MVR. At the end of the 5th year, the success rate of the repair group was 91% (13) in same study. Kang et al. Investigated the question of "revascularization alone or revascularization with repair in ischemic MR?" in a study. Repair and CABG were performed in 50 patients, and CABG was performed alone in 57 patients. According to their results, CABG with repair is a good option, but it was emphasized that only CABG is a better option in patients with moderate MR, especially if there are additional risk factors (advanced age, AF). They stated that it should be preferred due to positive effects in terms of LV remodeling (14).

Conclusion

In mitral valve insufficiency due to ischemia it is important to evaluate structural changes in the mitral valvular apparatus

preoperatively and intraoperatively. The choice of techniques to eliminate the existing pathology in the repair is crucial. One of these techniques is the Fundaro annuloplasty technique, which has the feature of a repair technique for primary pathology, just like in IMI. In addition, this method is advantageous because it can be performed in shorter XCL time. Low recurrence rate after repair and positive effects on ventricular remodeling can be achieved with this technique.

Declaration of conflict of interest

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References

1. Dr. Mustafa PAÇ ve arkadaşları. Kalp ve Damar Cerrahisi. 2004. Edinsel Mitral Kapak Hastalıkları: 487-88,507-08
2. Dr. Enver DURAN. Kalp ve Damar cerrahisi.2004. cilt 2. Kombine Kapak ve İskemik Kalp Hastalığı.1235-44
3. Lawrence H.Cohn, L.Henry Edmunds,Jr. Cardiac Surgery In The Adult 2003, Pathophysiology of Mitral Valve Disease:903-27,Valvuler and Ischemic Heart Disease: 1058-74
4. Fundarò P, Pocar M, Moneta A, Donatelli F, Grossi A, Posterior mitral valve restoration for ischemic regurgitation. *Ann Thorac Surg*, 2004 Feb;77(2):729-30.
5. LungB. Management of ischaemic mitral regurgitation. *Heart* 2003;89:459-464.
6. Agnieszka Ciarka, MD, PhDa, Jerry Braun, MD, Victoria Delgado, MDa, Michel Versteegh, MD, PhD, Eric Boersma, MSc, PhDc, Robert Klautz, MD, PhD, Robert Dion, MD, PhD, Jeroen J. Bax, MD, PhDa,*, and Nico Van de Veire, MD, PhDa. Predictors of Mitral Regurgitation Recurrence in Patients With Heart Failure Undergoing Mitral Valve Annuloplasty. *Am J Cardiol* 2010;106:395–401)
7. Kumanohoso T, Otsuji Y, Yoshifuku S, et al. Mechanism of higher incidence of ischemic mitral regurgitation in patients with inferior myocardial infarction: quantitative analysis of left ventricular and mitral valve geometry in 103 patients with prior myocardial infarction. *J Thorac Cardiovasc Surg* 2003;125:135–43.
8. Miller DC. Ischemic mitral regurgitation redux—To repair or to replace? *J Thorac Cardiovasc Surg* 2001;122:1059–62.
9. Filsoufi F, Flores KQ, Chen RH, Cohn LH, Nathan NS, Byrne JG et al. Does coronary artery bypass grafting alone correct moderate ischaemic mitral regurgitation? *Circulation* 2001;104:168- 175.

10. Kim YH, Czer LS, Soukiasian HJ, De Robertis M, Magliato KE, Blanche C et al. Ischemic mitral regurgitation: revascularization alone versus revascularization and mitral valve repair *Ann Thorac Surg* 2005;79:1895-1901.
11. Adem İ Diken, MD,1 Garip Altınta, MD,2 Adnan Yalçinkaya, MD,1 Gökhan Lafçı, MD,2 Onur Hanedan, MD,2 Kerim Çağlı, MD2 Surgical Strategy for Moderate Ischemic Mitral Valve Regurgitation: Repair or Ignore? *The Heart Surgery Forum* #2014-337 17 (4), 2014
12. Langer, F., Borger, M. A., Czesla, M., Shannon, F. L., Sakwa, M., Doll, N.,... & Schäfers, H. J. (2013). Dynamic annuloplasty for mitral regurgitation. *The Journal of Thoracic and Cardiovascular Surgery*, 145(2), 425-429.
13. A. Marc Gillinov, MDa Per Nils Wierup, MDa* Eugene H. Blackstone, MDa,b. Is repair preferable to replacement for ischemic mitral regurgitation? A. Marc Gillinov, MDa Per Nils Wierup, MDa* Eugene H. Blackstone, MDa,b. *The Journal of Thoracic and Cardiovascular Surgery* • Volume 122, Number 6 1125
14. Duk-Hyun Kang, Mi-Jeong Kim, Soo-Jin Kang, Jong-Min Song, Hyun Song, Myeong-Ki Hong. Mitral Valve Repair Versus Revascularization Alone in the Treatment of Ischemic Mitral. *Circulation*. 2006;114:I-499-I-503