

Neochordae as the primary technique for repair of isolated posterior mitral leaflet prolapse: a comparison to traditional techniques

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Abstract

Aim: Posterior mitral valve leaflet (PMVL) prolapse repair using CV5 Gore-Tex neochordae without leaflet resection used as the primary method of repair was compared to traditional quadrangular leaflet resection.

Material and methods: Prospective data were collected in 186 consecutive mitral valve repair patients; January 2003 to March 2006. Bi-leaflet repairs were required in 63 and PMVL only in 54. The latter group formed the study group; 23 patients underwent repair using neochordae prepared to specific intraoperative measurements using a single suture technique and an annuloplasty ring without any resection (group I). The remaining 31 patients underwent more traditional quadrangular resection and an annuloplasty ring (group II). We compared immediate and short-term results between these groups.

Results: Preoperative mitral regurgitation was severe in 87% (20/23) and 94% (29/31) respectively. Ten patients in group I (43%) and 2 patients in group II (6%) had prolapse of more than one posterior leaflet segment. Combined CABG was performed in 35% and 42% of patients respectively. Intraoperative post-repair transoesophageal echocardiography revealed trivial or less residual regurgitation in all patients in group I and 94% of group II. At follow-up (FU) 100% of the patients in group I (median FU 12.9 months) and 81% in group II (median FU 24.3 months) were in NYHA class I ($p < 0.05$). Transthoracic echocardiography FU revealed trivial or no mitral regurgitation in group I – 82% and group II – 56% ($P = 0.11$). There was one operative death in group II and 1 late death in each group.

Conclusions: Gore-Tex neochordae used as the primary repair technique for PMVL prolapse is reproducible and shows comparable and possibly superior results to traditional quadrangular resection/reconstruction repair.

Key words: posterior mitral valve leaflet prolapse, polytetrafluoroethylene (PTFE), mitral regurgitation.

Streszczenie

Cel: Porównanie zastosowania sztucznych strun ścięgniętych z goreteksu CV5 (*neochordae CV5 Gore-Tex*) bez resekcji płatkka jako głównej metody naprawczej wypadania tylnego płatkka zastawki mitralnej z tradycyjną czworokątną resekcją płatkka.

Materiał i metody: Prospektywnie zebrano dane 186 kolejnych pacjentów poddanych naprawie zastawki mitralnej od stycznia 2003 do marca 2006 r. Naprawa *bileaflet* konieczna była w 63 przypadkach, zaś PMVL w zaledwie 54. Ostatnia z grup stanowiła grupę badaną; 23 pacjentów poddano naprawie z użyciem sztucznych strun ścięgniętych przygotowanych według specjalnych pomiarów śródoperacyjnych z użyciem techniki pojedynczego szwu oraz pierścienia do annuloplastyki, bez resekcji (grupa I). Pozostałych 31 pacjentów poddano bardziej tradycyjnej resekcji czworokątnej z pierścieniem do annuloplastyki (grupa II). Dokonano porównania natychmiastowych i krótkoterminowych wyników w obydwu grupach.

Wyniki: Przedoperacyjna ostra niedomykalność mitralna występowała u odpowiednio 87% (20/23) i 94% (29/31) badanych. U 10 (43%) pacjentów z grupy I oraz 2 (6%) pacjentów z grupy II występowało wypadanie więcej niż jednego tylnego segmentu płatkka. Jednoczasowe CABG z wymianą zastawki mitralnej wykonano odpowiednio u 35% i 42% pacjentów. Śródoperacyjna ponaprawcza echokardiografia przezprzełykowa wykazała nieznaczną lub szczytkową (*trivial or less residual*) niedomykalność u wszystkich pacjentów w grupie I i u 94% z grupy II. W badaniu kontrolnym 100% pacjentów z grupy I (badanie kontrolne po 12,9 mies., mediana) i 81% z grupy II (badanie kontrolne po 24,3 mies.) znalazło się w klasie NYHA I ($p < 0,05$). Echokardiografia przezklatkowa w badaniu kontrolnym wykazała nieznaczną niedomykalność mitralną bądź jej brak (*trivial or no mitral*) w grupie I – 82% i w grupie II – 56% ($p = 0,11$). W grupie II nastąpił jeden zgon śródoperacyjny; w każdej z grup miał miejsce jeden zgon późny.

Wnioski: Sztuczne struny ścięgnięte z goreteksu stosowane jako podstawowa technika naprawcza w wypadaniu tylnego

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Introduction

Degenerative disease of the mitral valve is the most common cause of mitral regurgitation (MR) in developed countries [1, 2]. Mitral valve repair is the surgical procedure of choice as opposed to mitral valve replacement in the treatment of mitral valve prolapse [3–5]. Repair of posterior mitral valve leaflet (PMVL) alone has been shown to have a better long-term outcome than anterior mitral valve leaflet (AMVL) or bi-leaflet prolapse repairs [6, 7]. PMVL repair has traditionally been by quadrangular resection of the prolapsed segment with or without a sliding procedure as well as annuloplasty [8–10]. The clinical use of polytetrafluoroethylene (PTFE) neochordae in conjunction with leaflet resection was described by David et al. over 15 years ago [11] with good long-term outcome [12, 13] but mostly used in AMVL repairs.

Recently PMVL repair without any resection of leaflet tissue is being adopted [14, 15]. We describe our technique of PMVL prolapse repair with PTFE neochordae without leaflet resection and compare these results with patients who underwent the more traditional quadrangular resection technique.

Material and methods

All patients who underwent mitral valve procedures between January 2003 and March 2006 were reviewed and 186 underwent mitral valve repairs. Mitral valve repairs for prolapse of the mitral valve leaflet were carried out in 117 patients. Among these, 63 patients underwent bi-leaflet repairs with the remaining 54 patients undergoing repair of PMVL prolapse only. The latter patients formed this study group. Patient details were prospectively collected and entered into the PATS (Patient Administration Tracking Service, Dendrite clinical systems, UK) database.

Of the 54 patients, 23 patients underwent PMVL repair by PTFE neochordae implantation without any leaflet resection (group I). The remaining 31 patients underwent more

płatka zastawki mitralnej jest metodą odtwarzalną, wykazującą wyniki porównywalne, a potencjalnie nawet lepsze aniżeli tradycyjna resekcja czworokątna/naprawa rekonstrukcyjna.

Słowa kluczowe: wypadanie tylnego płatka zastawki mitralnej, sztuczne struny ścięgnowe, niedomykalność mitralna.

traditional PMVL quadrangular resection and sliding valvuloplasty repair (group II). A mitral ring/band annuloplasty was performed in 53 patients, excluding one.

Preoperatively, all patients in both groups had detailed trans-thoracic echocardiogram (TTE) to assess the degree of mitral regurgitation and anatomy of the valve along with assessment of left ventricle (LV) function. Intraoperative trans-oesophageal echocardiogram (TOE) was also performed in the majority of patients prior to initiation of cardiopulmonary bypass (CPB) as well as after the repair procedure. Patients were followed up with further TTE.

Mitral regurgitation was categorised as none, trivial, mild, moderate or severe by quantifying the jet of regurgitation (vena contracta). Ejection fraction (EF) was categorised as good (> 50%), moderate (30–49%) or poor (< 30%). The preoperative demographics of both groups are shown in Table I. There was one patient in each group with MV prolapse caused by infarcted papillary muscle due to ischaemia. In addition in group II there were 3 patients with partially treated endocarditis.

Surgical technique

All the operations were performed through a midline sternotomy and patients were placed on CPB through aorto-bicaval cannulation. Cold blood hyperkalaemic cardioplegic solution at 4°C was used to arrest the heart in diastole. The mitral valve was exposed through a standard incision in the inter-atrial groove and maintained using a self-retaining mitral valve retractor. The entire mitral valve apparatus was then carefully assessed under direct vision and mode of failure confirmed.

Patients in group I had the prolapsed posterior mitral valve segments repaired by implantation of PTFE neochordae with no leaflet resection performed by a single surgeon between October 2003 and March 2006. Neochordae were made from CV 5 Gore-Tex sutures (W.L. Gore & Associates, Inc. U.K.) to specific defined measurements using a special measuring device (Geister catalogue #03-5409; Geister, Tuttingen, Germany), and were made with either 1, 2 or 3 loops, as previously described [16]. Initially, these PTFE neochordae were made during the surgical procedure; however, in the latter part of the study, after getting the necessary approval, these PTFE neochordae were made in bulk prior to surgery and re-sterilised. Hence, pre-made PTFE neochordae with either 2 or 3 loops and having lengths between 16 mm and 28 mm were available 'off the shelf' in 2 mm incremental sizes. The length of PTFE neochordae to be used in any specific patient was determined by intraoperative measurement of the length of adjacent normal chordae using the specially designed measuring device [16].

Tab. I. Preoperative demographic data of patients

	Group I	Group II	p value
n	23	31	
Gender (male)	65%	90%	0.02
Sinus rhythm	70%	39%	0.03
LV ejection fraction > 30%	87%	87%	0.99
Severe mitral regurgitation	87%	94%	0.41
Associated tricuspid valve disease	78%	61%	0.18
Mitral valve pathology – degenerative	96%	87%	0.31

LV – left ventricle.

The selected PTFE neochordae having 2 or 3 loops were then sutured to the papillary muscle using a Gore-Tex pledget buttress, with the loops always on the 'inlet' side of the papillary muscle. The free end of each neochordal loop was then secured to the atrial surface of the prolapsed PMVL segment with another Gore-Tex CV5 suture passed through the leaflet and the knot tied on the ventricular surface of the leaflet [16]. An annuloplasty ring (Carpentier Edwards-Physio ring; Edwards Lifesciences, Irvine, U.S.A.) or band (Calvin Galloway Future band; Medtronic, Inc. Minneapolis, U.S.A.) was sized on the basis of both the inter-trigonal distance and surface area of the anterior leaflet and secured with 2/0 interrupted braided polyester sutures.

Patients in group II underwent traditional quadrangular resection of the prolapsed segment and sliding valvuloplasty if required with implantation of an annuloplasty ring or band. Two patients required additional PTFE neochordae because of prolapse adjacent to the resected segment. All 54 patients underwent post-repair TOE assessment of the repair by a consultant cardiologist following discontinuation of CPB and findings documented. The surgical characteristics and repair techniques used in both groups are shown in Table II. A customised measured annuloplasty band was used in 1 patient in group II, in place of a commercially available ring/band.

Follow-up

All patients were contacted between June and August 2006 and their New York Heart Association (NYHA) status was assessed. They were also invited to attend a follow-up TTE examination. Follow-up (FU) data of patients not contactable or unable to attend this TTE examination were gathered from their most recent examinations. On the follow-up TTE, LV function in terms of ejection fraction, degree of MR, degree of tricuspid regurgitation (TR), AMVL and PMVL length (measured from the annulus to the free edge of the leaflet in the midpoint) as well as coaptation width were assessed and collected. Postoperative TTE findings of the 2 groups are shown in Table 3. A minimum of 6 months follow-up period was completed in 96% (52/54): 100% in group I and 94% in group II.

Statistical analysis

All statistical analysis was performed using the SPSS 14.0 for Windows software package (SPSS Inc, Chicago, IL USA). Continuous variables are expressed as mean and standard deviation. Non-parametric data were analysed using Mann-Whitney U test while descriptive data were analysed using Chi-squared test and Fisher's exact test when appropriate. A "p" value of less than or equal to 0.05 was deemed significant.

Results

The mean age of the 54 patients studied was 64 ± 5.5 years and the operative mortality was 1.85% with a single in-hospital death in group II. The median inter-quartile ran-

ge (IQR) postoperative hospital length of stay was 10 (7.14) and 8 (6.12) days respectively for the two groups.

Preoperative differences between the groups were: group I had fewer male patients (65%) while 90% of patients in group II were males ($p = 0.02$), normal sinus rhythm was present in 70% and 39% ($p = 0.03$) of the patients respectively (Table I). There was no difference between groups in the degree of preoperative mitral regurgitation, associated tricuspid valve regurgitation or LV function. The most common cause of prolapse was myxomatous degenerative valve disease with chordal elongation or rupture (Table I).

Isolated valvular surgery was performed in only 30% of patients (7/23) in group I and this was similar in group II (35% (11/31) $p = 0.7$). The majority of patients had concomitant coronary artery bypass grafting (CABG), aortic or tricuspid valve surgery as well as surgery for atrial fibrillation (Table II). Isolated P2 prolapse was present in only 52% (12/23) of patients in group I and more patients in group II had single segment prolapse (90%; 29/31; $p < 0.01$). The mean number of PTFE neochordae used in group I was 5.1 ± 1.2 . The average neochordal length used was 21.1 ± 2.5 mm (range 16–26 mm). Additional repair techniques used included papillary muscle repositioning and chordal transfer as detailed in Table II. We tended during this study period to predominantly use the CG Future Band in patients in group I. We did not observe systolic motion of the anterior mitral leaflet (SAM) in any patient in either group during this study period.

The median postoperative follow-up was 12.4 months and 24.9 months respectively in the groups. There were 2 late deaths, one in each group, and 2 patients were lost to follow-up in group II. The actuarial 3-year follow-up survival was $96\% \pm 4\%$ for group I and $93\% \pm 5\%$ for group II (log rank = 0.71) (Figure 1). None of the surviving patients had moderate or more MR. However, more patients in group II had mild as opposed to trivial or no mitral regurgitation ($p = 0.05$; Table III). The PMVL length measured on follow-up TTE was longer in group I patients (Table III). All patients

Tab. II. Surgical characteristics and repair techniques

	Group I	Group II	p value
n	23	31	
CABG*	8	13	0.6
Multiple valve procedures (\pm TVS, \pm AVS)	8	11	0.96
Arrhythmia surgery	1	12	< 0.01
Prolapse of 1 PMVL segment only	13	29	< 0.01
Number of PTFE neochordae used*	5.1 ± 1.2	0.1 ± 0.4	< 0.01
Chordal transfer	0	3	0.2
Papillary muscle repositioning	5	1	0.05
Medtronic CG future band	91%	65%	0.07
Carpentier Edwards ring	9%	29%	0.07

*expressed as mean \pm standard deviation; CABG – coronary artery bypass graft surgery; TVS – tricuspid valve surgery; AVS – aortic valve surgery; arrhythmia surgery – surgical treatment of atrial fibrillation.

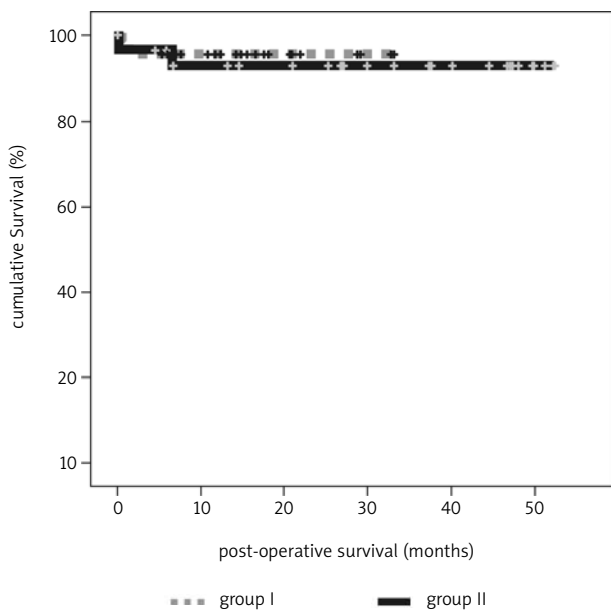


Fig. 1. Actuarial survival for the two groups.

in group I were in NYHA class I as opposed to only 81% of patients in group II ($p < 0.05$). The LV function on follow-up was moderate or better ($> 30\%$ EF) in 91% of patients in group I and 89% in group II, with no significant difference between the groups.

Discussion

It is accepted that long-term outcome after MV repair is better than after MV replacement [4–7]. In asymptomatic patients with severe MR the outcome is improved if surgery is performed before the onset of irreversible ventricular dysfunction [1, 17]. Prof. Carpentier’s technique of PMVL quadrangular resection with or without sliding valvuloplasty and annuloplasty [11] has been proven to have very good long-term outcome of over 20 years [2, 12]. Nevertheless, this approach requires additional techniques if there are more than one prolapsing PMVL segments, and the long-term stability of PTFE neochordae has been established.

PTFE chordae have been used for over 15 years [13] with good outcome, but to date primarily in repairing the AMVL [8]. PTFE is one of the most inert biocompatible materials, with a microporous structure that contains about 50% air by volume, allowing host tissue overgrowth and infiltration in the internodal spaces with a secure anchoring of fibrous sheath [18–20]. Over a period of time PTFE chordae are completely endothelialised and 5-0 PTFE has adequate breaking strength of greater than 1 kg.

A limitation of this study is that the overall FU period is longer in patients undergoing the more traditional quadrangular resection repair compared to the new technique, as primary repair of the prolapsed PMVL by implantation of PTFE neochordae was introduced at a later date. Nevertheless, more patients undergoing repair by implantation of PTFE neochordae with preservation of the entire

Tab. III. Postoperative observations

	Group I	Group II	p value
n	23	31	
NYHA class I	100%	81%	< 0.05
Normal sinus rhythm	68%	77%	0.44
No/trivial MR	82%	56%	0.11
No/trivial TR	55%	59%	0.05
EF $> 30\%$	91%	89%	0.84
AMVL length*	22.2 \pm 3.9	25.1 \pm 5.2	0.18
PMVL length*	18.4 \pm 3.5	16.0 \pm 2.3	< 0.05
LVESD*	35.8 \pm 4.8	33.4 \pm 7.8	0.05
LVEDD*	47.0 \pm 4.8	45.3 \pm 8.0	0.18

*expressed as mean \pm standard deviation; MR – mitral regurgitation; TR – tricuspid regurgitation; EF – ejection fraction; LVESD – left ventricle end systolic dimension; LVEDD – left ventricle end diastolic dimension; AMVL – anterior mitral valve leaflet; PMVL – posterior mitral valve leaflet.

PMVL had trivial or no regurgitation on follow-up and were in NYHA class 1.

It has been generally accepted that the long-term results are better with PMVL repair than with AMVL or bi-leaflet repairs. David et al. had freedom from moderate or greater recurrent mitral regurgitation at 12 years FU of 80% for PMVL, 65–67% for anterior or bi-leaflet repairs [8]. Our early results of no patients having greater than mild mitral regurgitation are more than comparable to these results.

Preserving the posterior leaflet tissue may increase the area for leaflet coaptation, thereby leading to a more durable repair but with the proviso that the coaptation zone remains on the posterior third of the mitral valve [21]. Not surprisingly, we noted that the PMVL measured on follow-up was longer in patients in whom we preserved the entire posterior leaflet, which would contribute to increasing the coaptation width. The coaptation length of large posterior leaflets can be reduced by implanting shorter chordae, if there is concern of causing SAM. We did not observe any post-repair SAM of the mitral valve in this study.

Maximal conservation of valvular and subvalvular apparatus is critical for optimal valve and ventricular function [6, 8]; hence PTFE neochordae repair of mitral valve prolapse without resection of leaflet tissue may better preserve left ventricular systolic function. During the isovolumetric contraction phase of the cardiac cycle, the mitral valve is drawn into the ventricular cavity, causing shortening in the longitudinal axis and an increase in the short axis of the ventricle. This enables myocardial fibres to stretch more and consequently increase the tension and contraction and hence the stroke volume. David and coworkers have observed extensive resection of posterior leaflet tissue greater than 1.5 cm width, and plication in a single point impairs contractility of the posterior wall of the LV [3].

PTFE neochordae implantation repair without any leaflet resection of PMVL is a simple reproducible technique. Our technique of using pre-made Gore-Tex neochordae having multiple loops allowed the repair to be done quicker and with confidence that correct chordal length is achieved.

The majority of our patients had more than 5 neochordae implanted on the PMVL, but with only 2 sutures. This is a helpful technique when there are multiple segments of prolapse. In this series of patients with isolated PMVL prolapse, 22% of patients had prolapse involving more than one segment and the majority of these patients were treated with the new technique.

We have shown that the short-term outcome of posterior mitral leaflet repair by implantation of neochordae without leaflet resection is comparable and possibly superior to the more traditional leaflet resection techniques [11]. The long-term effects of this reasonably new technique need to be further monitored.

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