

# A 20-year experience with mitral valve repair with artificial chordae in 608 patients

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Supplemental material is available online.

**Objective:** Mitral valve repair with artificial chordae for degenerative mitral regurgitation is widely adopted. We evaluated long-term results of mitral repair with expanded polytetrafluoroethylene sutures (GORE-TEX CV-5; W. L. Gore & Associates, Inc, Flagstaff, Ariz).

**Methods:** Between November 1986 and November 2006, 608 consecutive patients underwent mitral repair with artificial neochordae. Mean age was  $55 \pm 11$  years (15–85 years); 433 (71.2%) were male. Valve disease was purely degenerative in 555 patients (91.3%). Prolapse of anterior, posterior, or both leaflets was present in 47 (7.7%), 308 (50.7%), and 253 (41.6%), respectively. Atrial fibrillation was associated in 117 (19.2%). In 125 cases (20.5%), additional surgical procedures were performed. Follow-up was complete at a median of 5.7 years (interquartile range 2.2–9.8 years, range 0–19.4 years).

**Results:** In-hospital mortality was less than 1% (6 deaths). Overall and cardiac late mortalities were 6.6% and 3.9% (34 and 24 deaths). Kaplan–Meier survival at 15 years was 84% (95% confidence interval 75%–90%). Freedoms from endocarditis, thromboembolic events, reoperation, and recurrent mitral regurgitation at 15 years were 97% (95% confidence interval 93%–99%), 92% (87%–95%), 92% (88%–95%), and 85% (78%–91%), respectively. Sinus rhythm was restored in 75% (33 patients) after surgical atrial fibrillation correction. Calcification of GORE-TEX neochordae was never reported.

**Conclusion:** Mitral valve repair with GORE-TEX artificial chordae is effective, safe, and associated with low operative mortality and low rates of valve-related complications at long-term follow-up. Artificial chordae showed excellent biologic adaptation, retaining flexibility and tension with time.

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Mitral valve (MV) repair has become the procedure of choice for the treatment of mitral regurgitation (MR), with superior results relative to MV replacement.<sup>1,2</sup> MV repair is feasible in as many as 95% of cases of degenerative MV regurgitation,<sup>3</sup> despite the presence of complex lesions. The Carpentier quadrangular resection, with or without concomitant sliding plasty, is considered the standard surgical technique to correct posterior leaflet prolapse.<sup>4</sup> Various types of reconstructive procedures, including triangular resection, chordal transfer, chordal shortening, edge-to-edge technique, and papillary muscle repositioning, have been used to repair anterior leaflet prolapse. MV repairs with these techniques are not always satisfactory, and some of these procedures are considered technically demanding.<sup>4–6</sup>

Chordal replacement with expanded polytetrafluoroethylene (ePTFE) sutures (GORE-TEX sutures; W.L. Gore & Associates, Inc, Flagstaff, Ariz) was introduced experimentally by Frater and colleagues<sup>7</sup> in the early 1980s. Current use in clinical practice has permitted repair of complex mitral lesions with a now widely adopted technique.<sup>3,8,9</sup>

**Abbreviations and Acronyms**

AF	= atrial fibrillation
CI	= confidence interval
ePTFE	= expanded polytetrafluoroethylene
IQR	= interquartile range
MR	= mitral regurgitation
MV	= mitral valve
SAM	= systolic anterior motion

In this study, we report 20 years of experience of MV repair with ePTFE suture in 608 consecutive patients. To our knowledge, this is the largest reported series and the longest follow-up study of this technique.

**Patients and Methods**

From 1986 to 2006, a total of 608 consecutive patients with severe MR underwent MV repair with artificial neochordal implantation at our institution. There were 433 men (71.2%) and 175 women. Ages ranged from 15 to 85 years (mean  $55.5 \pm 11.5$  years). Table 1 shows patients' clinical profiles and the prolapsing leaflets. In cases of mild ascending aorta dilation (5 patients) and absence of significant aortic valve disease (3 patients), there was no concomitant surgical indication. The cause of valve disease was purely degenerative in 555 patients (91.3%). Fifty-three patients (8.7%) had degenerative MR complicated by infective endocarditis. Atrial fibrillation (AF) was present in 117 patients (19.3%). Coronary angiography was performed in patients older than 50 years and in those with suspected coronary artery disease.

**Operative Procedures**

The approach to the heart was exclusively by means of a midsternotomy until April 2006; since then, most of the operations have been performed with a videoendoscopic port-access approach through a right minithoracotomy. MV repair was performed with cardiopulmonary bypass under moderate hypothermia. Myocardial protection was achieved by both intermittent cold blood cardioplegia and topical cooling for midsternotomy, whereas in minimally invasive surgery cold crystalloid solution Custodiol (Koehler Chemie, Alsbach-Haenli, Germany) was infused. The MV was approached through a standard left atriotomy with an incision made just behind the interatrial groove. The entire MV apparatus was then carefully inspected, and prolapse of the leaflets was identified by examining the level of the free margin of each portion of the leaflets. Resection of the posterior leaflet according to the Carpentier technique<sup>4</sup> was performed in 351 patients (57.7%). Indications for GORE-TEX chordoplasty, in combination with posterior leaflet resection, were mainly as follows: (1) bileaflet prolapse (posterior resection plus neochordae on anterior mitral leaflet); (2) need for a small posterior mitral leaflet tissue resection to provide a better coaptation against anterior mitral leaflet, with neochordal implantation mandatory in this case to ensure a more stable connection between leaflet and papillary muscles; and (3) Barlow disease, where reconstruction after extensive posterior leaflet resection can leave an area without native chordal support. Such technique was used less frequently in the last few years. Actually, we prefer to resect only posterior mitral leaflet tissue excess parallel to the margin. This means to resect an adequate

**TABLE 1. Clinical characteristics of patients with severe mitral regurgitation**

No. of patients	608
Age (y, mean $\pm$ SD)	$55.5 \pm 11.5$
Male (No.)	433 (71.2%)
Electrocardiography (No.)	
Sinus rhythm	491 (80.7%)
Atrial fibrillation	117 (19.3%)
Mitral valve pathology (No.)	
Pure degenerative	555 (91.3%)
Degenerative plus endocarditis	53 (8.7%)
Prolapsing leaflet (No.)	
Anterior	47 (7.7%)
Posterior	308 (50.7%)
Bileaflet	253 (41.6%)
New York Heart Association functional class (No.)	
I	155 (26.7%)
II	270 (46.6%)
III	134 (23.1%)
IV	21 (3.6%)
Associated disease (No.)	
Total cases	125 (20.5%)
Coronary artery disease	24 (3.9%)
Atrial septal defect or patent foramen ovale	43 (7.1%)
Aortic valve disease	14 (2.3%)
Tricuspid valve regurgitation	13 (2.1%)
Dilatation of ascending aorta	8 (1.3%)
Previous cardiac surgery (No.)	3 (0.5%)
Left ventricular ejection fraction <40%	47 (7.7%)

segment of prolapsing tissue close to the free margin, to align P2 height with P1 height, when this scallop appears of normal size; however, it creates a reduction that leaves about 1.5 cm height from the annulus. Where ruptured or elongated chordae were attached and resected, we replaced with ePTFE sutures.

Prolapse of the anterior leaflet was managed by chordal replacement with ePTFE sutures only. Other techniques, such as triangular resection, chordal transfer, or chordal shortening, have never been used at our institution. We described the technique of chordal replacement with ePTFE suture in a previous publication.<sup>10</sup> Briefly, we use an ePTFE double-armed suture (GORE-TEX CV-5) that is passed through the papillary muscle with a mattress technique and is reinforced with autologous pericardial pledgets (or, rarely, with GORE-TEX pledgets) on both sides of the muscle. Each end of the suture is then fixed to the free margin of the prolapsed leaflet and is reinforced with a small autologous pericardial pledget (or, less frequently, a small GORE-TEX pledget). The length of the artificial chordae is adjusted to maintain the corresponding free margin of the leaflets at the desired level in the ventricular cavity. To determine the correct length of the artificial chordae so that an adequate coaptation area is obtained and any significant prolapse is reduced, the neochordae are tied at the end of all the other repair procedures after the ventricular cavity is filled with saline solution.

In 48 selected cases (7.9%), after the leaflet repair was accomplished, if thin or fragile natural chordae tendineae were identified, even if not elongated or ruptured, a couple of artificial chordae were implanted as a protective function ("sentinel" neochordae) to

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