Mitral valve (MV) repair with expanded polytetrafluoroethylene (ePTFE) sutures has proven to be simple, versatile, and durable technique for the treatment of mitral valve regurgitation (MR). The ePTFE is known for its strong resistance to tension, and is judged to be unbreakable under physiological condition. The loop technique using premeasured ePTFE neochordae was employed from August 2005 for 290 consecutive MV repair. Among those 290 patients, there was only one case of recurrent MR due to rupture of the ePTFE neochordae. We report a case of intermediate failure of CV-5 ePTFE neochordae due to rupture and its electron microscope views.

**Keywords:** mitral valve repair, mitral regurgitation, ePTFE, ruptured neo-chordae, loop technique

### Case Report

In January 2010, a 60-year-old woman presented with severe mitral regurgitation (MR). Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) revealed severe MR due to anterior leaflet prolapse with rupture and elongation of the chordae tendineae. Surgery was performed via right mini-thoracotomy with femoral cannulation for cardiopulmonary bypass. After achieving cardiac arrest, the interatrial groove was incised to expose the roof of the left atrium. A left atrial incision was made close to the MV and a custom-made retractor was positioned to reveal the valve. She was found to have anterior leaflet prolapse with ruptured and elongated chordae at segments A1, A2, and A3. Four pairs of CV-5 ePTFE neochordae were attached to the anterolateral and posteromedial papillary muscles, and then six neochordae were created from both sides of the papillary muscles. Annuleoplasty of the MV was also done using a 32 mm Carpentier-Edwards Physio ring II (Edwards Lifesciences, Irvine, California, USA). Intraoperative TEE showed no residual MR, as did postoperative and discharge TTE. The patient was discharged from hospital on postoperative day 9.
Three years later, the patient was readmitted with recurrent MR. TEE and TTE revealed moderate/severe MR with anterior leaflet prolapse, so re-operation was scheduled. Midline sternotomy was performed, with cardiopulmonary bypass being initiated after ascending aorta and bicaval cannulation. The left atrium was opened through the interatrial groove and the MV was examined. It was found that one of the CV-5 neochordae attached to A3 and one CV-5 fixing suture for the loop had ruptured, although each knot was intact (Fig. 1). The other four neochordae seemed to be working well and had retained their original length and pliability. The anterior leaflet with neochordae and the Physio ring were resected. Then a 25 mm Open Pivot Heart Valve (Medtronic, Minneapolis, Minnesota, USA) was implanted and tricuspid annuloplasty was also performed with a 28 mm MC3 (Edwards Lifesciences, USA). The patient had an uneventful postoperative recovery and returned to New York Heart Association functional class 1 with good function of the prosthetic MV.

Examination of the excised anterior mitral leaflet confirmed rupture of an ePTFE neochordae and a fixing suture (Fig. 2). Histological evaluation of the ePTFE remnants showed a collagenous reaction surrounding the synthetic material and infiltration of lymphocytes and plasma cells into the ePTFE fibers was noted, suggesting an inflammatory response due to a foreign body reaction. Scanning electron microscopy confirmed these findings (Fig. 3). Based on microscopic examination of the ruptured ePTFE, there were no changes such as calcification. Instead, there was tapering of the neochorda at the site of rupture, suggesting that it may have been injured intraoperatively and may have gradually become weaker, eventually resulting in complete rupture.

Comment

MV repair using ePTFE neochordae has achieved excellent results over the long term\textsuperscript{1,2} and ePTFE neochordae have been used for a variety of mitral reconstruction procedures. At our institution, 460 patients with MR underwent MV repair between January 1998 and March 2013. The loop technique using premeasured Gore-Tex neochordae was employed from August 2005 for 273 consecutive MV repairs, including 119 posterior, 56 anterior, and 99 bi-leaflet procedures. Among those 273 patients, there was only one case of recurrent MR due to rupture of the ePTFE neochordae.

Minatoya and colleagues performed a structural analysis of ePTFE sutures implanted as artificial chordae at 7.5 and 8.6 years after initial MV repair. No calcification was observed either macroscopically or microscopically, and
the sutures retained their normal flexibility. Salvador and colleagues reported on a large series of patients undergoing MV repair with artificial chordae, and stated that there were no failures due to malfunction of the ePTFE chordae during a 20-year follow-up period. Thus rupture of ePTFE neochordae is an extremely rare cause of recurrent MR. Our literature review identified some previous reports of reoperation due to late rupture (6–14 years postoperatively), which was related to calcification of the ePTFE neochordae. Buntany, et al. reported rupture of an ePTFE suture in a patient at 14 years after chordal replacement for rheumatic MV disease. Histopathologic examination demonstrated severe calcification of the ePTFE sutures, and they speculated that this calcification had caused the rupture. Coutinho and colleagues reported 2 cases of rupture of CV-5 ePTFE neochordae at 6 and 11 years postoperatively, which were also associated with histological calcification of the neochordae. Furthermore, Farivar and colleagues reported a patient with calcification and degradation of ePTFE neochordae, leading to rupture at 11 years after initial MV repair. On the other hand, Fukunaga and associates reported a patient with recurrent MR after MV repair using ePTFE neochordae. There was no chordal rupture, but dystrophic calcification of fibrous tissue covering the ePTFE sutures led to sclerosis and shortening of the chordae with resultant loss of coaptation of the mitral leaflets. Infiltration of lymphocytes and plasma cells was detected, suggesting an inflammatory response or potential foreign body reaction. Like this case of Fukunaga, et al., calcification of the ePTFE sutures was not recognized histologically in our patient. Interestingly, the other ePTFE neochordae of the anterior leaflet were intact in our patient, retaining their original length and pliability. Because the consolidation of the anterior leaflet by regurgitant was recognized, however, a valve replacement with mechanical valve was selected. It is well known that ePTFE shows histological changes over time, so it is important to minimize mechanical stress on the neochordae. In this respect, we should pay attention to fixing the neochordae symmetrically in relation to the bilateral papillary muscles and we should also add neochordae prophylactically at normal sites. In our patient, intraoperative damage to the ePTFE cannot be excluded since rupture occurred at a comparatively early stage. It was considered that surgical damage of ePTFE sutures was the cause.

Fig. 3  Electron microscopic views of the ruptured ePTFE neochorda.
Therefore, the importance of gentle operative manipulation when using ePTFE was suggested. Although MV repair with ePTFE neochordae usually achieves excellent long-term results, these artificial chordae may not have adequate strength to withstand the forces acting on them during the mid-term postoperative period. Use of ePTFE neochordae for reconstruction represents a significant advance in the technique of MV repair, demonstrating excellent reliability and durability. However, surgeons should be aware of this rare complication when using ePTFE materials. From 2011, we have made some changes to the loop technique. In this technique, a neo-chordae was composed with a primary short loop set (5 mm) fixed to the papillary muscle and a secondary loop between rough zone of the mitral leaflet and the primary short loop. The effective length of the neo-chordae was adjusted with the secondary loop by reference with saline injection test and comparison with a reference leaflet. In addition, reusable clip from neurosurgery field are used to tie the loop sutures firmly in the correct position without slipping (loop-in-loop technique). As a result of our experience with this case, we have changed from CV-5 to CV-4 ePTFE for the first loop set of neochordae and have had no failures to date.

Disclosure Statement

The author declares that he has no conflict of interest.

References