Leaflet plication with neochordae implantation: A novel technique for mitral valve repair

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CENTRAL MESSAGE
We proposed leaflet plication with neochordae implantation as a novel technique for repairing the redundant prolapsing P2 segment.

The middle scallop of the posterior leaflet (P2) is the most common site of mitral valve prolapse, and mitral valve repair is superior to mitral valve replacement in the treatment of degenerative mitral valve prolapse.¹ Carpentier’s method of quadrangular resection with annular plication² is considered the gold standard for the treatment of mitral valve prolapse of the posterior leaflet; moreover, this revolutionary nonresection method conducted using artificial chordae has long-term effects comparable with those of leaflet resection.³ However, for redundant posterior leaflets, an extra “sliding leaflet plasty”⁴ or the “butterfly resection technique”⁵ is warranted to decrease the height of the posterior leaflet and avoid systolic anterior motion (SAM). Sliding leaflet plasty and butterfly resection are somewhat complicated and time-consuming. Herein, we introduce a novel, simplified mitral valve repair technique involving leaflet plication using artificial chordae implantation for the redundant prolapsing P2 segment.

SURGICAL TECHNIQUE
The technique was performed in 10 patients, and all of them provided written informed consent. A minimally invasive approach was employed, and cardiopulmonary bypass was established by femoral arterial and venous cannulation. A right minithoracotomy with a 5-cm-long incision was performed over the fourth intercostal space. After we temporarily arrested the heart using antegrade cold blood cardioplegia, the left atrium was accessed via the interatrial groove. The prolapsed P2 was gently lifted with forceps; then, each mitral valve segment and successively the subvalvular apparatus—including the anterior leaflet, P1, P3, chordae tendineae, and anterolateral and posteromedial papillary muscles—were checked carefully.

Figure 1 shows the key procedures involved in this novel technique. The height of the prolapsed P2 segment was measured using a small scale; then, 2 dots on the P2 segment located approximately 1.5 to 2 cm perpendicular to the mitral annulus were made, and these were set as the artificial chordae implantation sites. A polytetrafluoroethylene (PTFE) suture (CV-4 Gore-Tex; WL Gore & Associates Inc) was passed through the fibrous tip of the anterolateral papillary muscle using the figure-of-eight suture technique. Each arm of the PTFE suture was passed through the left target dot twice via the plicated double-layer leaflet to create length-adjustable neochordae. The same process was repeated for the posteromedial papillary muscle using the figure-of-eight suture technique. Each arm of the PTFE suture was passed through the left target dot twice via the plicated double-layer leaflet to create length-adjustable neochordae.

A semirigid annuloplasty ring was then implanted, and saline solution was injected into the left ventricle to assess valvular competence. The

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neochordal length was regulated in case of residual mitral regurgitation (MR). A saline test was performed to verify whether the coaptation height was satisfactory, and the 2 PTFE sutures were then tied respectively with at least 10 knots on the atrial plane of the posterior leaflet. Finally, the atrium was closed, and the patient was weaned from cardiopulmonary bypass after we confirmed the absence of residual regurgitation using transesophageal echocardiography (Video 1).

RESULTS
Of the 10 patients, 7 (70.0%) were male, and the mean patient age was 55.5 ± 6.6 years. Severe, moderate-to-severe, and moderate MR were observed in 4 (40.0%), 4 (40.0%), and 2 (20.0%) patients, respectively. All of the patients underwent mitral valve repair using our novel technique. No deaths or major adverse events occurred after surgery, and all the patients had an uneventful recovery. A 3-month follow-up was conducted in all patients after the surgery, and none of the patients developed recurrent MR.

TABLE 1. Detailed change of echocardiographic data of all patients

| Variable     | Preoperation | Follow-up | P value |
|--------------|--------------|-----------|---------|
| LVEDV, mL    | 134 ± 34     | 100 ± 25  | .004    |
| LVESV, mL    | 42 ± 14      | 34 ± 8    | .039    |
| LVDd, mm     | 58 ± 7       | 51 ± 5    | .013    |
| LVDs, mm     | 37 ± 5       | 34 ± 3    | .034    |
| LVEF, %      | 69 ± 5       | 66 ± 4    | .317    |

Values are presented as mean ± standard deviation. LVEDV, left ventricular end-diastolic volume; LVESV, left ventricular end-systolic volume; LVDd, left ventricular end-diastolic diameter; LVDs, left ventricular end-systolic diameter; LVEF, left ventricular ejection fraction.
Detailed changes in the transthoracic echocardiographic data before surgery and at follow-up are presented in Table 1.

DISCUSSION

Leaflet resection followed by either annular plication or sliding leaflet plasty demonstrated excellent long-term outcomes and is hence the classic approach for repairing posterior leaflet prolapse.6,7 However, both the resection techniques share the following drawbacks8: (1) chordae elongation caused by long-term MR may result in residual prolapse; (2) excess posterior leaflet tissue may cause SAM; and (3) extensive resection of P2 may result in an insufficient coaptation height. Thus, unsatisfactory repair results are inevitable. The “respect approach” for mitral valve repair, which preserves the leaflet tissue, is being widely used in recent years and presents long-term outcomes comparable with those of resection techniques.3,9 Although the artificial chordae length can be adjusted to an extent, dealing with a redundant posterior leaflet seems ineffective. One derived technique10 that reduced the length of the P2 segment through longitudinal plication in the leaflet root showed outstanding early outcomes; however, the method was complicated and time-consuming.

Our technique is easy to perform and presents excellent outcomes in the repair of redundant prolapsing P2 segment. Unlike the technique of Calafiore and colleagues,10 which demands 3 to 6 interrupted “U” sutures passing from the annulus to P2 to decrease the height of the prolapsed P2 segment, our technique allowed us to directly implant the artificial chordae on the P2 segment approximately 1.5 to 2 cm perpendicular to the mitral annulus and plicate the prolapsed leaflet. Our technique not only prevents left ventricular outflow tract obstruction with SAM by means of the excess posterior leaflet tissue but also reduces the tension between the leaflet tissue and artificial chordae to avoid avulsion. Moreover, our technique can be used to repair other leaflets; in fact, the technique has shown remarkable results in several of our previous cases. Nevertheless, a longer follow-up duration and a larger patient cohort are needed to demonstrate the durability and stability of our novel technique.

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