hronic ischemic mitral regurgitation (MR) is a cause of congestive heart failure in patients with ischemic cardiomyopathy. Various mitral valve plasty (MVP) techniques have been reported, but the best surgical intervention is still controversial and the development of new techniques is necessary to give better outcome for patients with ischemic MR. We initiated our original procedure called “papillary muscle sandwich plasty” in 2004 and in this study, we evaluated its early and late surgical results.

Methods

Patients

Of 602 ischemic heart disease patients, 46 underwent MVP for ischemic MR between 1999 and 2007 and of them, 23 patients since 2004 underwent papillary muscle sandwich plasty. The mean age of the patients was 67 (47–82) years and there were 16 men and 7 women. The patients’ preoperative characteristics, examination results and operative procedures are summarized in Table 1.

According to preoperative echocardiography, the mean left ventricular diastolic and systolic diameters were 54±6 mm and 43±7 mm, respectively. The mean mitral annulus diameter and tenting height was 29.5±2.4 mm and 12.0±2.8 mm, respectively. The grade of preoperative MR was severe in 10 patients and moderate in 13. Mitral ring-annuloplasty was performed in 9 (39%) patients and left ventricular volume reduction in 5 (22%). Postoperative early and late results were evaluated. The mean follow-up period was 24±10 months (range 7–39 months).

Technique

Our technique of “sandwich plasty” is usually performed...
through a left atrial incision under cardiac arrest, but in some patients who require a left ventriculoplasty, the mitral valve can be approached through a left ventricular incision. The first step is the papillary muscle head approximations of the anterior and the posterior mitral valve leaflets in order to achieve coaptation of the 2 leaflets. At the anterolateral commissural portion, a Teflon-pledged 3-0 Ticron suture with a double-armed needle is passed through the papillary muscle head of the posterior leaflet and through the papillary muscle head of the anterior leaflet, reinforced with another Teflon patch. The same approximation suture is made at the posteromedial commissural portion. We sometimes experience slight difficulty in viewing the head of the papillary muscle of the anterior leaflet, but that can be resolved by slight retraction of the chordae connecting to the anterior leaflet. The second step is the mitral annuloplasty using a just-sized Cosgrove ring or Carpenter-Edwards Physio-ring. If the annual diameter is larger than 30 mm, it is downsized using 30 mm annual ring.

**Statistical Analysis**

All calculations were performed using StatView version 5.0 software (SAS Institute, Inc, Cary, NC, USA). Continuous data are expressed as the mean±standard deviation. Student’s t-test, the chi-square test, Kaplan-Meier method and log-rank test (Mantel-Cox) were used and a P-value of less than 0.05 was considered to be significant.

**Results**

After surgery, the left ventricular diastolic diameter was significantly (P<0.05) decreased from 54±6 mm to 52±8 mm. There were no significant changes in the left ventricle systolic diameter, fractional shortening or ejection fraction. Tenting height of the mitral valve significantly (P<0.01) decreased from 12.0±2.8 mm to 6.6±1.9 mm after surgery. Residual mild MR occurred in 1 patient (4%), but moderate or severe MR was not observed (Table 2).

One patient died of postoperative heart failure and the another 3 patients died of mediastinitis caused by methicillin-resistant Staphylococcus aureus. Thus, the late results were evaluated in 19 cases. In the follow-up study, moderate or severe MR occurred in 1 patient (4%), but moderate or severe MR was not observed (Figure 1).

The MR-free rate at 2 years after surgery was 93% in the Sandwich plasty and 63% in the other procedures.

**Table 2. Mitral Regurgitation Before and After Surgery**

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>Left ventricular geometry</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LVDd (mm)</td>
<td>54±6</td>
<td>52±8</td>
<td>&lt;0.05</td>
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<tr>
<td>LVDs (mm)</td>
<td>43±7</td>
<td>41±8</td>
<td>NS</td>
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<tr>
<td>LVFS (%)</td>
<td>21±6</td>
<td>21±6</td>
<td>NS</td>
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<tr>
<td>LVEF (%)</td>
<td>40±10</td>
<td>42±11</td>
<td>NS</td>
</tr>
<tr>
<td>Mitral valve geometry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annulus (mm)</td>
<td>29.5±2.4</td>
<td>25.7±2.2</td>
<td>NS</td>
</tr>
<tr>
<td>Tenting height (mm)</td>
<td>12.0±2.8</td>
<td>6.6±1.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>10 (43%)</td>
<td>0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Moderate</td>
<td>13 (57%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>0</td>
<td>1 (4%)</td>
<td></td>
</tr>
<tr>
<td>None-trivial</td>
<td>0</td>
<td>22 (96%)</td>
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</table>

Values are mean±SD.
Abbreviations see in Table 1.
Discussion

In the treatments of ischemic heart disease, surgical procedures for coronary artery bypass grafting (CABG) have been almost standardized, including off-pump CABG. The biggest concern recently is the surgical management of ischemic cardiomyopathy, which includes treatment for coronary artery disease, mitral valve regurgitation, dilated heart and impaired cardiac function. Among these, treatment of ischemic MR is a valuable first step. Ischemic MR is recognized as functional regurgitation and a common cause of congestive heart failure, caused by the process of myocardial infarction remodeling. The etiology of ischemic MR is complicated because it results from a variable combination of annular dilatation and remodeling of the subvalvular apparatus. Various techniques such as annuloplasty, edge-to-edge technique and chordal cutting of the mitral valve have been reported, but although the annular dilatation may be effectively treated, methods for addressing the subvalvular remodeling have not been standardized.

The importance of papillary muscle displacement by left ventricular dilatation has been recently recognized and several procedures for papillary muscle repositioning have been reported. Hvass et al reported a simple procedure called the papillary muscle sling method, which created close contact of both papillary muscles using a Gore-Tex tube. Menicanti et al reported papillary muscle imbrication without a mitral ring. Arai et al also reported the efficacy of a mitral complex remodeling procedure consisting of 3 major concepts: division and reconstruction of the secondary chords, undersized annuloplasty, and bilateral papillary muscle relocation. The aim of our technique, sandwich plasty, is the reduction of the tethering effect by fixing 2 heads of the papillary muscle connecting to the chordae of both the anterior and posterior leaflets. Generally, the length of the chordae does not change in ischemic functional MR, so approximation of the papillary muscle heads achieves good coaptation of the anterior and posterior leaflets. Initially, we did not use a mitral annular ring in the sandwich Plasty because we thought sufficient coaptation could be obtained by approximation of the papillary muscle heads, but in the recent cases we have used annular rings to maintain a sufficient coaptation zone on the beating heart and to prevent further annular dilatation in the future. Sandwich plasty is a simple procedure for functional MR and there are no contraindications with respect to left ventricular size, tenting height or tenting area. However, large anatomical variances may prevent this procedure because the balance of the papillary muscle and connecting chordae is very important. Ramsheyi et al morphologically classified the mitral papillary muscles into 4 types, which the single papillary muscle (type I) might be a technically challenging target for sandwich plasty because fixing the huge head of the papillary muscle might be technically difficult.

Before the introduction of the sandwich plasty, we used to perform other MVP procedures such as the Alfieri procedure (edge-to-edge repair) or chordal reconstruction. Preoperative values, such as the left ventricular and mitral valve geometry, and grade of MR were almost the same as those of patients who underwent sandwich plasty, but postoperative residual mild or moderate MR occurred in 11 of 23 patients undergoing the other procedures. In the follow-up study, the MR-free rate after sandwich plasty was significantly higher than that after other procedures (Figure 2).

Postoperative late results in patients with ischemic cardiomyopathy have not been satisfactory. In this study, a patient with residual prominent ischemic MR died in the follow-up study. Actively combining surgery is necessary to improve the outcome of patients with severe ischemic cardiomyopathy. Ventricular remodeling surgery is reported as an effective procedure for surgical relocation of the posterior papillary muscle tip in the setting of a severely dilated left ventricle. Matsui et al reported the efficacy of overlapping ventriculoplasty combined with papillary muscle plication in patients with a severely dilated heart. Suma et al reported the selection of a suitable surgical procedure for endstage cardiomyopathy based on intraoperative echocardiography evaluation. In combined surgery, selected multiple procedures need to be completed within a limited time. The results of our sandwich plasty were favorable, but the greatest advantage of this method is its simplicity. In conclusion, our original “sandwich plasty” was effective at the early and late periods and may improve the prognosis of patients with ischemic heart failure.

References