A simple method of functional posterior leaflet height reduction with the loop technique to avoid systolic anterior motion

Kazumasa Tsuda, MD, Naoki Washiyama, MD, Masahiro Hirano, MD, Norihiko Shiiya, MD

PII: S2666-2507(23)00388-7
DOI: https://doi.org/10.1016/j.xjtc.2023.10.008
Reference: XJTC 1537

To appear in: JTCVS Techniques

Received Date: 11 September 2023
Revised Date: 2 October 2023
Accepted Date: 9 October 2023

Please cite this article as: Tsuda K, Washiyama N, Hirano M, Shiiya N, A simple method of functional posterior leaflet height reduction with the loop technique to avoid systolic anterior motion, JTCVS Techniques (2023), doi: https://doi.org/10.1016/j.xjtc.2023.10.008.

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Copyright © 2023 The Authors. Published by Elsevier Inc. on behalf of The American Association for Thoracic Surgery
A simple method of functional posterior leaflet height reduction with the loop technique to avoid systolic anterior motion

Kazumasa Tsuda, MD, Naoki Washiyama, MD, Masahiro Hirano, MD, Norihiko Shiiya, MD

First Department of Surgery, Hamamatsu University School of Medicine, Hamamatsu, Japan

Disclosure Statement: None
Funding Statement: None

Corresponding Author: Kazumasa Tsuda
First Department of Surgery, Hamamatsu University School of Medicine
1-20-1 Handayama, Higashi-ku, Hamamatsu 431-3192, Japan
Tel: +81-53-435-2776, E-mail: kzmstd@hama-med.ac.jp

Word count: 750 words
Loops of predetermined length were secured on the atrial aspect of the large P2 leaflet.

To avoid postoperative SAM, we reduce the functional posterior leaflet height by securing the loops of predetermined length on the atrial aspect of P2 leaflet 15-mm away from the posterior annulus.
In repairing the mitral valve with a large prolapsing posterior leaflet, height reduction of the posterior leaflet is frequently required to prevent systolic anterior motion (SAM). Leaflet resection with the sliding leaflet technique has commonly been used; however, it is technically demanding especially through a minimal invasive approach. Tabata et al. reported a modified chordal replacement technique “chordal foldoplasty” to reduce the posterior leaflet height without leaflet resection by securing the neochordae on the middle portion of the atrial aspect of the prolapsing scallop. However, adjusting the slippery expanded polytetrafluoroethylene (ePTFE) neochordae to the desired length may be difficult. We have introduced the loop technique for chordal foldplasty, in which the loop length was determined preoperatively. We report the detail of our novel technique, which was employed in 5 patients with degenerative mitral regurgitation and a large prolapsing posterior leaflet (IRB 23-201, 10/4/23). All patients provided written informed consent for publication of this study data. Surgical technique

We determined the loop length using trans-thoracic echocardiography, transesophageal echocardiography, or 4-dimensional computed tomography (4D-CT). 4D-CT images were analyzed with a medical image post-processor (Synapse Vincent, Fujifilm,
Tokyo, Japan). The loop length was based on the distance between the free margin and the tip of papillary muscle of the corresponding anterior leaflet in late systole (Supplementary video). The number of loops was determined based on the extent of prolapse. Loop neochordae were prepared using the CV-4 ePTFE suture (WL Gore and Associates, Flagstaff, AZ) and the Shibata Chordae System (Geister, Tuttlingen, Germany) immediately before surgery.

The operations were performed through a right mini-thoracotomy incision in 4 patients, and through a median sternotomy in the remaining patient who underwent concomitant aortic valve replacement. After confirming the consistency between the determined loop length and intraoperative measurement, the prepared loop bundles were secured to the papillary muscles to which corresponding anterior leaflet chordae were attached, using a pledgetted mattress suture. Then the loops were fixed on the atrial aspect of the posterior leaflet approximately 15 mm away from the posterior annulus with a 5-0 monofilament figure-of-eight suture. The points of loop fixation were ink-marked using a hand-made 15-mm caliper (Figure 1, Video 1). Finally, annuloplasty was performed using a semi-rigid partial band. The band size was based on the inter-trigone distance, which can also be measured preoperatively (Supplementary video).

All the 5 patients showed uneventful recovery. Postoperative echocardiography
showed deep leaflet coaptation with no residual mitral regurgitation and no SAM.

Postoperative 4D-CT also showed excellent deep coaptation near the posterior annulus and no SAM (Video 2). Patients were summarized in Table 1.

Discussion

The loop technique has been introduced to avoid the shortening of slippery ePTFE neochordae during knot-tying. In this technique, the chordal length after repair was adjusted by the loop length and the point of loop fixation. When the posterior leaflet is extremely large, leaflet resection for height reduction has been added to prevent SAM². However, such procedures are relatively technically demanding, especially through a mini-thoracotomy approach. Tabata’s foldplasty can be a solution to avoid complex leaflet resection procedure. However, the problem of knot-tying remains. Our novel technique can be a solution for both problems, which can easily be performed through a minimally invasive approach. Regardless of the size of posterior leaflet, appropriate functional leaflet height can be achieved by predetermined loop length. When 4D-CT is not available, the loop length can also be determined by echocardiography or intraoperative measurement.

The point of loop fixation was set at 15 mm away from the posterior annulus. This is
based on the knowledge that posterior leaflet height exceeding 15 mm carries the risk of SAM. Because the affected leaflet usually shows thickening in this area, the risk of tear is considered to be negligible. Using a 5-0 monofilament figure-of-eight suture for loop fixation, we have experienced no cases of leaflet tearing or chordal fracture. To achieve deep enough coaptation (>10mm), the anterior leaflet needs to be large enough; the sum of anterior leaflet height and functional posterior leaflet height after repair (15 mm) should be at least 20 mm larger than the expected antero-posterior mitral annular diameter after ring annuloplasty (roughly two thirds of the ring size). Therefore, it is crucial to measure the anterior leaflet height and confirm it is sufficiently large.

There are several limitations. The number of patients was small, and long-term outcomes are lacking. All the patients had P2-related disease and underwent annuloplasty with a semi-rigid partial band. Although we believe that our technique is applicable to other posterior leaflet segments and works with a total ring, further experiences are needed.

In conclusion, functional height reduction using the loop neochordae is a simple and reproducible technique to avoid SAM.

Ethical statement

This study was approved by the Institutional Review Board of Hamamatsu University
School of Medicine (23-201).

Conflict of interest: none declared.
References


Table 1.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Lesion</th>
<th>A2/P2</th>
<th>Ring</th>
<th>Loop</th>
<th>CPB</th>
<th>AXC</th>
<th>Expected Coaptation Depth*3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>F</td>
<td>P2</td>
<td>26.0/24.0</td>
<td>PF 30</td>
<td>2x2 A19, P19</td>
<td>144</td>
<td>98</td>
<td>10.5</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>M</td>
<td>P2 lateral</td>
<td>28.1/24.7</td>
<td>CG 34</td>
<td>1x3 A18</td>
<td>143</td>
<td>99</td>
<td>10.3</td>
</tr>
<tr>
<td>3</td>
<td>61</td>
<td>F</td>
<td>P2 lateral</td>
<td>25.9/22.5</td>
<td>PF 30</td>
<td>1x2 A20</td>
<td>107</td>
<td>67</td>
<td>10.5</td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>M</td>
<td>P2</td>
<td>26.4/23.8</td>
<td>PF 32</td>
<td>2x2 A24, P22</td>
<td>122</td>
<td>68</td>
<td>10.1</td>
</tr>
<tr>
<td>5*4</td>
<td>75</td>
<td>M</td>
<td>P2 medial</td>
<td>26.7/19.8</td>
<td>PF 30</td>
<td>1x2 P19</td>
<td>144</td>
<td>104</td>
<td>10.9</td>
</tr>
</tbody>
</table>

*1: Data are shown as number of bundles x number of loops. 2x2 means that a total of 4 loops were used.

*2: The length of loops fixed to the anterior papillary muscle is shown as A00, while that fixed to the posterior papillary muscle is shown as P00.

*3: Expected Coaptation Depth = \{“Anterior leaflet height” + “Functional posterior leaflet height after repair (15mm)” − “Antero-posterior diameter of the band (roughly 2/3 of the labeled size)\}/2

*4: Concomitant aortic valve replacement
A2/P2: leaflet height of A2/P2 segment, CPB: cardiopulmonary bypass time, AXC: aortic crossclamp time, PF: Physio Flex annuloplasty ring (Edwards Lifescience, Irvine, CA), CG: CG Future annuloplasty band (Medtronic, Minneapolis, MN)
Figure 1. Operative pictures of the functional height reduction with the loop technique (Case 2).

(A) A very large P2 leaflet with torn chordae, (B) A bundle of 3 loops secured to the anterior pupillary muscle, (C) Marking at a 15-mm distance from the P2 annulus, (D) Loop fixation on the atrial aspect of P2, (E) Loops secured on the middle portion of P2, (F) No regurgitation.
Video 1. Surgical video of the functional height reduction with the loop technique (Case 1).

Video 2. Pre- and post-operative echocardiography and 4-dimensional computed tomography (Case 1 and 2).

Supplementary video. Pre-operative assessment and preparation for “functional height reduction with loop technique”