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Commentary: Surgical mitral plasticity: Another brick in the wall?

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In an Expert Opinion, Michler¹ retraces the outcomes of the Cardiothoracic Surgical Trials Network trials.²⁻⁴ In summary, mitral valve (MV) repair was found to be unnecessary in cases of moderate ischemic mitral regurgitation (IMR), and MV replacement was preferable in cases of severe IMR. High IMR recurrence 2 years postsurgery (32.3% if preoperative IMR was moderate, and 58.8% if severe) underlies similar clinical outcomes and left ventricular (LV) remodeling at 2-year follow-up. However, for successful repair, LV remodeling clearly improved in patients with mild or low IMR at follow-up compared with those with moderate or severe IMR. In other words, good surgery improved results. The better clinical outcome reported by 2 previous smaller randomized trials^{5,6} for moderate IMR could be justified by better echocardiographic results. Fattouch and colleagues⁵ reported no patients with moderate or high IMR (0/45) after 32 months, and Chan and colleagues⁶ reported 1 in 27 (3.7%) at 1 year.

Michler¹ analyzes the different aspects of the disease in terms of IMR grade, LV dysfunction and remodeling, presence of LV scars, and quality of the coronary circulation to give an opinion on how to drive the surgical correction

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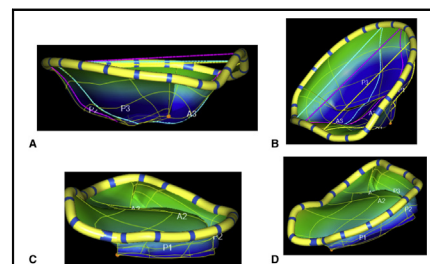
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Severe ischemic mitral regurgitation; 3D annular and leaflets reconstruction in systole.

CENTRAL MESSAGE

Surgical mitral plasticity, increasing of anterior leaflet area and length, and cutting second-order chords balances the mitral adaptation to regurgitation.

according to IMR severity. While restrictive mitral annuloplasty (RMA) remains a valid surgical option for moderate IMR in presence of LV enlargement, poor coronary targets, or baseline inferior–posterior–lateral wall motion abnormalities, as reported by others,⁷ in the author's opinion, overcorrective RMA does not benefit severe IMR, as it can exacerbate leaflet tethering. RMA could require complementary ventricular surgical procedures such as papillary muscle (PM) approximation. In support to this strategy is a small study⁸ that reported 5-year recurrence of moderate or severe IMR in 27% of 37 patients undergoing RMA with PM approximation.

Evaluating the issue from another perspective, IMR (the effect) is a consequence of chordal tethering induced by PM(s) displacement (the cause). In clinical practice, there are patients with minimal or no MR despite dilated hearts⁹ and severely displaced PMs.¹⁰ In such instances, the effect is not directly proportional to the cause because the MV has intrinsic capabilities to adapt to regurgitation. This is due to mitral plasticity, a mechanism that includes changes of MV leaflets and tendinous chords to improve leaflet coaptation in response to tethering. This mechanism, although reported for many years in experimental¹¹⁻¹⁶ and clinical studies,^{9,10,12,17-20} is widely underrecognized. The increase in length and area of MV leaflets and length of the tendinous chords⁹ is mediated by reactivated endothelial-to-mesenchymal transition and matrix remodeling, driven by stretching beyond a physiologic limit^{12,13} and the consequent activation of transforming growth factor- β (TGF- β). However, other factors, such as

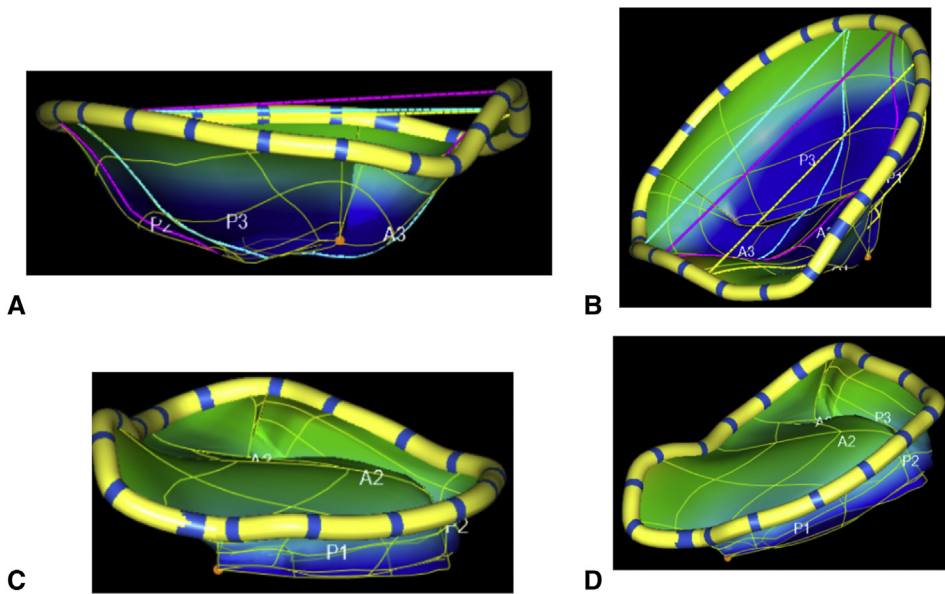


FIGURE 1. Patient with severe IMR; 3-dimensional annular and leaflets reconstruction in systole. A and B, Preoperatively, both mitral leaflets are tethered inside the left ventricle (*blue area*). C and D, After anterior leaflet augmentation, second-order chords cutting and restrictive mitral annuloplasty. The tenting volume nearly disappeared. The anterior leaflet reaches the annular plane, and the posterior leaflet is fixed in vertical position. No IMR was detected.

stretching itself, activation of angiotensin II receptors, and ischemia, can exacerbate TGF- β upregulation, causing exuberant endothelial-to-mesenchymal transition²¹ with residual increase of thickness,¹⁸ cellular proliferation, and reduction of leaflets growth. The net effect of this disproportionate response can be unbalanced adaptation of the MV leaflets and a progressive increase of IMR grade. This series of events can be counteracted by using antagonists of angiotensin II receptors, such as losartan, that inhibit TGF- β upregulation and reduce the profibrotic changes of MV leaflets without eliminating adaptive growth.²¹ PM displacement causes chordal tethering and IMR, but it is the extent of mitral plasticity that determines IMR severity.

The importance of the adaptive mechanism of MV in reducing IMR grade can be the rationale of surgical mitral plasticity, a surgical strategy aimed at changing MV adaptation from unbalanced to balanced.²² It involves augmenting the surface of the anterior leaflet with a pericardial patch²³ and cutting the second-order chord. The increase of the anterior leaflet area is an established technique, but chordal cutting is controversial. The possibility of impairing LV function still limits its application, although clinical studies seem to deny this possibility.²⁴ Chordal cutting is the key to eliminate chordal tethering (chords that insert closer to the annulus are more sensitive to PM displacement²⁵) and to allow the augmented anterior leaflet to move toward the posterior leaflet. Restrictive mitral annuloplasty fixes the posterior leaflet in vertical position and completes the procedure (Figure 1).

Nowadays, there is increased awareness that MV repair for IMR is a complex procedure requiring comprehension of the mechanisms, and the best approach to interfere with a process that varies from patient to patient. It must be recognized that surgical techniques for IMR correction are not yet standardized, and it is difficult to decide whether surgery is indicated when surgical results are unpredictable. We need to have an open mind and the possibility to choose among different strategies. PM approximation⁸ targets the cause, and surgical mitral plasticity the effect, of tethering. RMA could be sufficient but may necessitate additional procedures in some cases to challenge the risk of procedural failure.²⁶ The quest for the Holy Grail has begun.

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