method has the potential to revolutionize the field of cardiothoracic surgery. Most of all, the continued joint efforts of developmental biologists and material scientists and engineers in the area of cell printing may lead to faster tissue construction, a cornerstone to making regenerative medicine a clinical possibility.

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Selective reduction of the septolateral dimensions in functional mitral regurgitation by modified-shape ring annuloplasty

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Undersized annuloplasty is the conventional surgical treatment for functional mitral regurgitation (FMR).¹ The rationale of this approach is the reduction the annular diameter to force leaflet coaptation. When this technique is performed with a conventional annuloplasty prosthesis, the transverse and septolateral dimensions are proportionally reduced. However, it has been suggested that the main determinant of malcoaptation in FMR is the increase of the septolateral dimension.² Therefore, intercommissural distance reduction is probably unnecessary, if not detrimental (it may induce anterior leaflet folding and unnecessary reduction of the total mitral valve orifice area).

We herein present an alternative method for annuloplasty, designed to selectively reduce the septolateral dimension in FMR,

which is intended to improve the results of mitral repair in this challenging group of patients.³

Surgical Technique and Clinical Experience

A Carpentier rigid ring (Edwards Lifesciences Inc, Irvine, Calif) was chosen because it contains a metal core that can be reshaped. Prosthesis size was selected by measuring the intertrigonal distance and was undersized by 1 size. Before implantation, the ring was reshaped according to the sequence illustrated in Figure 1 by use of 2 tubing clamps. Shape modification created a prosthesis with the intertrigonal distance upsized by 1 size (and therefore normalized to the native valve intertrigonal dimension) and the septolateral distance undersized by 1 size (therefore, the septolateral dimension was doubly undersized), resulting in a nearly 2:1 intercommissural-septolateral ratio (as compared with the standard 4:3 ratio).

We used this approach in 14 patients with FMR between March and December 2003. There were 12 men and 2 women, with a mean age of 56 ± 11 years. Ten patients had ischemic and 4 had idiopathic cardiomyopathy. Preoperative mean functional class was 2.6 ± 0.6 . FMR was severe in 12 patients and moderate in 2 (the mean regurgitation grade was 3.8 ± 0.6). The mean coaptation depth was 1.09 ± 0.44 cm (range, 0.6-2.0 cm) and exceeded 1 cm in 6 patients.⁴ A complex regurgitant jet (eccentric or multiple) was detected in 9 patients.⁵ The mean tenting area was 2.1 ± 0.82 cm² (range, 1.3-4 cm²). The mean size of the implanted Carpentier ring was 29.7 ± 2.6 . Associated procedures included the edge-to-edge procedure (12 patients), coronary revascularization (10 pa-

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Figure 1. a, The original Carpentier Classic ring is shown. The prosthesis is first bent laterally by applying force on the points depicted by the x and by having the middle of the posterior portion of the prosthesis as the hinge. b, The initial result is a prosthesis with a wider intercommissural dimension. c, A second step is needed to restore the D shape of the prosthesis by bending the prosthesis at the level of the commissures (x). d, The final result is a prosthesis with a normalized intercommissural distance, a doubly undersized septolateral dimension, and a wider gap in the anterior portion of the annuloplasty device (a suture is passed across the gap to avoid future distension).

tients), and left ventricular remodeling (4 patients). There were no hospital deaths or complications related to the modified-shape prosthesis implantation. On predischARGE echocardiography, the mean mitral regurgitation (MR) grade was 0.5 ± 0.65 (decreased from a preoperative value of 3.8 ± 0.6 ; $P < .001$), 13 patients had no or trace MR, and 1 had mild (2+) residual MR. The planimetric mitral valve area was $2.8 \pm 0.49 \text{ cm}^2$. No significant gradient across the mitral valve was detected. During follow-up (5 ± 2.5 months; range, 1-11 months), there have been no deaths or rehospitalizations. The mean New York Heart Association functional class decreased from the preoperative value of 2.6 ± 0.6 to 1.1 ± 0.3 ($P < .0001$; 12 patients were in class I and 2 in class II). Nonsignificant progress in mean MR severity was observed during follow-up (from $0.5 \pm 0.65 \text{ cm}^2$ to $0.78 \pm 0.67 \text{ cm}^2$, $P = .4$). On 3-dimensional echocardiography, the annuloplasty prosthesis retained the modified shape with the 2:1 ratio between the intercommissural and the septolateral dimensions (Figure 2).

Figure 2. A follow-up 3-dimensional echocardiographic picture showing the typical D shape of the annuloplasty prosthesis, with a decreased septolateral dimension and with an approximately 2:1 ratio of the intercommissural-septolateral dimensions.

Discussion

Undersized annuloplasty, introduced by Bolling and associates,¹ is extensively used to treat FMR. The rationale is to force leaflet coaptation by reducing annular dimensions. The ideal undersized annuloplasty should primarily address the septolateral diameter without affecting the transverse diameter so as not to distort the anterior annulus, which is not dilated among these patients and provides adequate mitral valve area. The available ring prostheses were originally designed to correct degenerative or rheumatic disease and to reduce both the transverse and the septolateral diameters proportionally in the 4:3 ratio. Implanting a size 28 ring in a size 32 mitral valve reduces the intercommissural diameter by 12% and the septolateral diameter by only 25%, whereas when the shape of a Carpentier ring is modified, as has been documented by 3-dimensional echocardiography, the intercommissural length is not affected, and the septolateral diameter is reduced up to 50%. The satisfactory mitral valve area of $2.8 \pm 0.49 \text{ cm}^2$ found in our patients can be explained by a single dimension reduction.

We conclude that shape modification of a ring annuloplasty is an effective adjunct for valve repair in FMR. It provides effective apposition of the mitral leaflets without compromising transmitral flow and the shape of the anterior leaflet. The good immediate and early results encourage the extension of the indications for annuloplasty to subgroups with a high risk for recurrence, such as patients with a coaptation depth more than 1 cm and those with complex regurgitant jets. Dedicated prospective comparative studies with longer follow-up are needed to clarify the possible advantages of this technique over conventional undersized annuloplasty.

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