In Chapter 26 we identified two major pleats at the P1/P2 and P2/P3 junctions of the posterior leaflet, characterized their kinematics throughout the cardiac cycle, and approximated their surfaces with two filled (red and blue) triangular surfaces. These triangles, however, are only intended as a visualization device; we know that the actual pleats in the closed valve would bow inward toward one another as systolic left ventricular pressure acts on their outer ventricular surfaces to press their convex faces tightly together. We cannot appreciate such curvature in these studies, however, because of the limited spatial resolution of our sparse marker arrays.

In an attempt to better visualize the actual 3D shape of the valve leaflets, we developed a whole-valve model based on the anatomical dissection shown in Figure 2.3 in Antunes’ text MITRAL VALVE REPAIR, previously presented as our Figure 23.1. We enlarged and printed this figure, then cut along its perimeter, i.e., the dotted lines in Figure 27.1. This cutout was then used as a template on a sheet of aluminum foil, which was cut to this shape. Because this anatomical specimen is an unrolled mitral valve, we re-rolled the foil to join the left and right-most regions. We found that this 3D restoration process required, at minimum, four folds to allow leaflet coaptation in the model. After the model was completed and photographed, it was unrolled to reveal the folds as identified by the gray-shaded regions (1-4) in Figure 27.1.

![Figure 27.1 Cutout of Figure 23.1 (dotted lines) with required folds shaded gray. Anterior leaflet (AL) and posterior leaflet (PL) anatomy with posterior leaflet regions (P1, P2, P3) identified. Adapted from Antunes M.J. Mitral Valve Repair 1989, Page17, Figure 2.3, Verlag R.S.](image-url)
Figure 27.2 shows the resulting model as viewed from the left atrium. The fold between the anterior leaflet and P1 is identified as shaded region #3 in Figure 27.1, the fold between P1 and P2 by #2 in this figure, the fold between P2 and P3, by #1, and the fold between P3 and the anterior leaflet by #4. The model in Figure 27.2 appears to be a reasonable approximation of the mitral valve, which is not entirely surprising as it is anatomically-based. Our knowledge of the compound curvature of the anterior leaflet was required to fit the compound-curved anterior leaflet into the model. Although the radial curvature of the posterior leaflet edge must be concave to the left ventricle to allow coaptation with the anterior leaflet edge, the analysis in Chapter #41 shows that the radial curvature of the posterior leaflet belly is just as likely to be flat or convex as concave to the left ventricle, so posterior leaflet shape is also quite complex.

*Figure 27.2 Foil model based on the mitral valve cutout and folds in Figure 27.1.*
An interesting outcome of this 3D modeling process, besides suggesting the nature of the folds and leaflet curvatures required for coaptation in this curved geometry, is illustrated in Figure 27.3, showing the P2-P3 pleat from Figure 27.2 as viewed from the left ventricle. Note that, in order to prevent regurgitation, three convex surfaces in this pleat region must be pressed tightly together by systolic LVP; P2, P3, and the adjacent region of the anterior leaflet. We encounter this same mechanism for tightly sealing the aortic valve. Thus, one could say that the mitral valve can be viewed as two inverted aortic valves. Note that for most of the mitral valve coaptation regions, only two convex surfaces must be pressed into a fluid-tight seal, but for these critical pleated regions, required by the demands of 3D geometry, three forces must act to form a tight seal. It seems likely that the most vulnerable regurgitation sites would be at these pleat regions that require a more complex leaflet geometric interaction than the other regions of the coapting leaflets.

In the previous chapter, we mentioned that the pleats might geometrically stiffen the posterior leaflet against deformation due to left ventricular pressure. Figure 27.3 allows appreciation of how this might come about, with a potentially stiff rib being created by LVP acting on the P2/P3 fold.