Mitral Valve Replacement with a Calcified Annulus

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A densely and extensively calcified mitral annulus presents a formidable technical challenge during mitral valve repairs and replacements. Theoretically, leaving the calcium intact reduces the risk of particulate embolization and ventricular rupture but increases the risk of paravalvular leaks from the poor coaptation of the valve to the uneven rigid annulus. Removing the calcium provides a smoother and more pliable surface for the valve to coapt against but increases the risk of atrioventricular rupture. Atrioventricular ruptures can be repaired but the mortality after this event is very high. It takes only one nightmarishly long day trying to unsuccessfully repair an atrioventricular disruption after an isolated mitral valve operation to consider less radical approaches to the annular calcification.

An informal survey of surgeons at the Cleveland Clinic Foundation found that most never removed any calcium or only the minimal amount needed to seat the valve. This surprising yet practical approach is in contrast to the published manuscripts that describe extensive calcium removal for both repairs and replacement.[1–3] Understanding the pathology of mitral annular calcification may help explain this. Carpentier has shown that the calcification is posterior to the trigones in 98% of the cases, with the majority (73%) having the calcium localized to the posteromedial half of the annulus. More significantly, the calcium is restricted to the annulus in 77.5% of the cases, extends into the leaflets in 6%, and in <20% of the cases extensively involves the ventricular myocardium or papillary muscles.[1] This suggests that in only a minority of cases will the calcium be so extensive as to require radical debridement.

In this section, I will cover how I approach moderate to severely calcified annuli, including both conservative and radical management of the annular calcium.

PREOPERATIVE EVALUATION

The preoperative angiogram is very important not only to assess coronary anatomy, but also to show the amount of circumferential calcification and give a hint to the degree of valvular and ventricular involvement. A large dominant circumflex coronary artery remaining in the atrioventricular groove until it terminates as a posterior descending artery is at risk for injury or distortion during the mitral procedure.

Preoperative transthoracic or transesophageal echocardiography will provide useful information to help advise the patient as to the likelihood of a successful repair. Extensive leaflet calcium, failed previous repair, and severe rheumatic changes with mixed stenosis and regurgitation will usually require a mitral valve replacement.

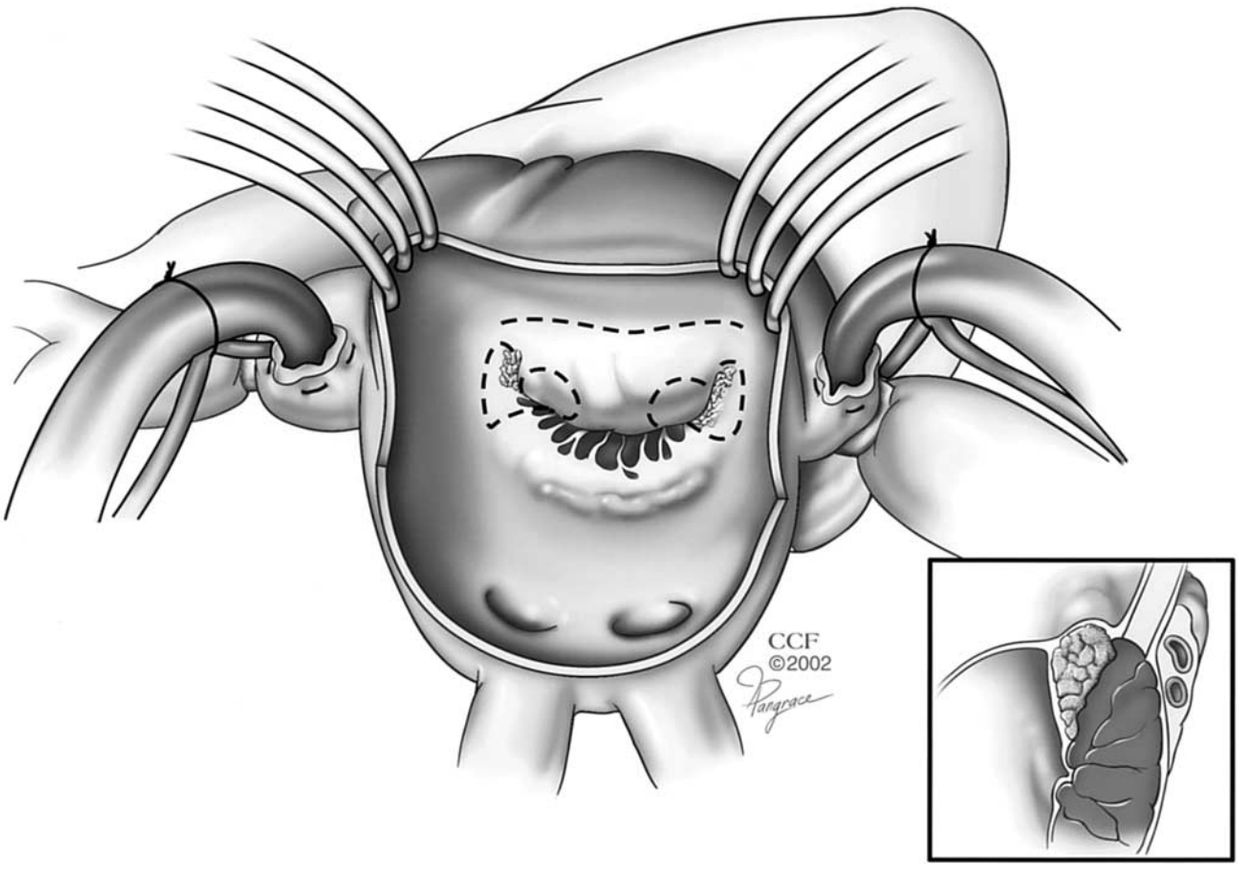
SURGICAL TECHNIQUE: EXPOSURE, MYOCARDIAL PROTECTION, AND SEQUENCE

I approach these patients through a complete median sternotomy rather than a less invasive approach in order to optimize exposure. In general, a trans-septal approach is used, especially when the left atrium is small or reconstruction of the entire fibrous skeleton may be necessary. Meticulous myocardial protection is critical because cross-clamp times may exceed 120 minutes if debridement and annular reconstruction are necessary. Blood-based cardioplegia is administered every 15 minutes, primarily retrograde but also antegrade in an effort to perfuse the right ventricle, which may be hypertrophied from longstanding secondary pulmonary hypertension. Coronary distal anastomoses are performed initially to provide a route for cardioplegia delivery and to avoid lifting the heart after mitral valve replacement and annular reconstruction.

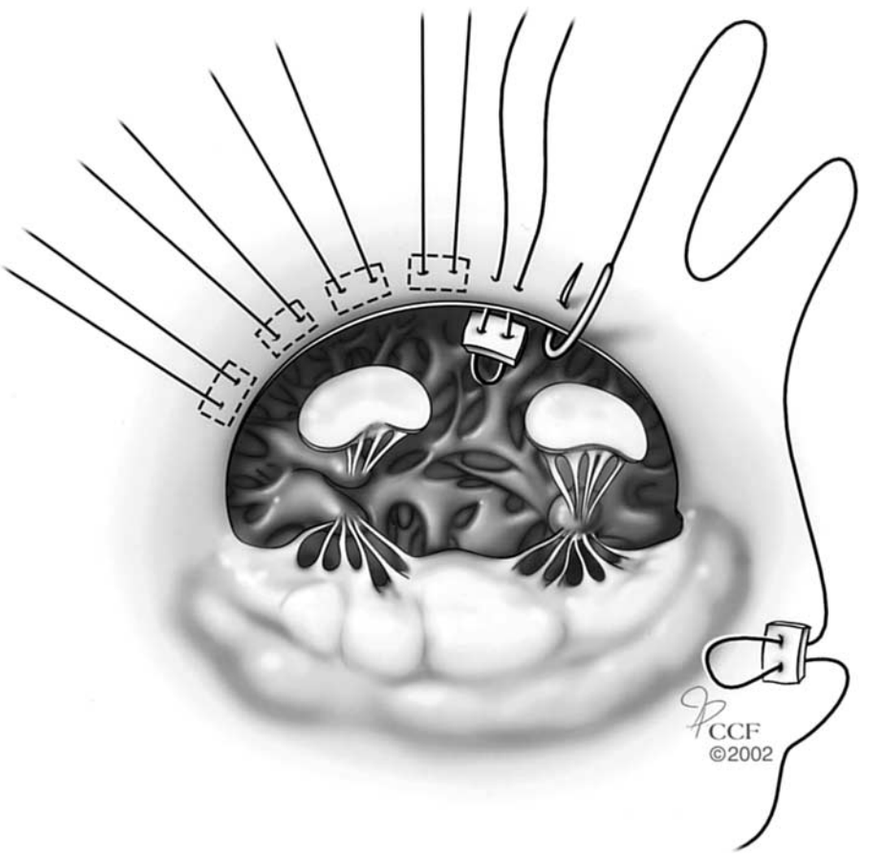
In all cases, papillary–annular continuity is preserved in order to maintain ventricular function by saving as much of mitral subvalvular apparatus as possible. This also may reduce the risk of atrioventricular disruption. Calcium and thickened tissue is removed from the leaflets to facilitate this and to prevent tissue from interfering with the motion of the prosthetic valve leaflets.

Inspection of the valve should focus on these issues: 1) feasibility of repair, 2) depth of annular calcification, 3) involvement of leaflets with calcium, and 4) size of the mitral orifice.

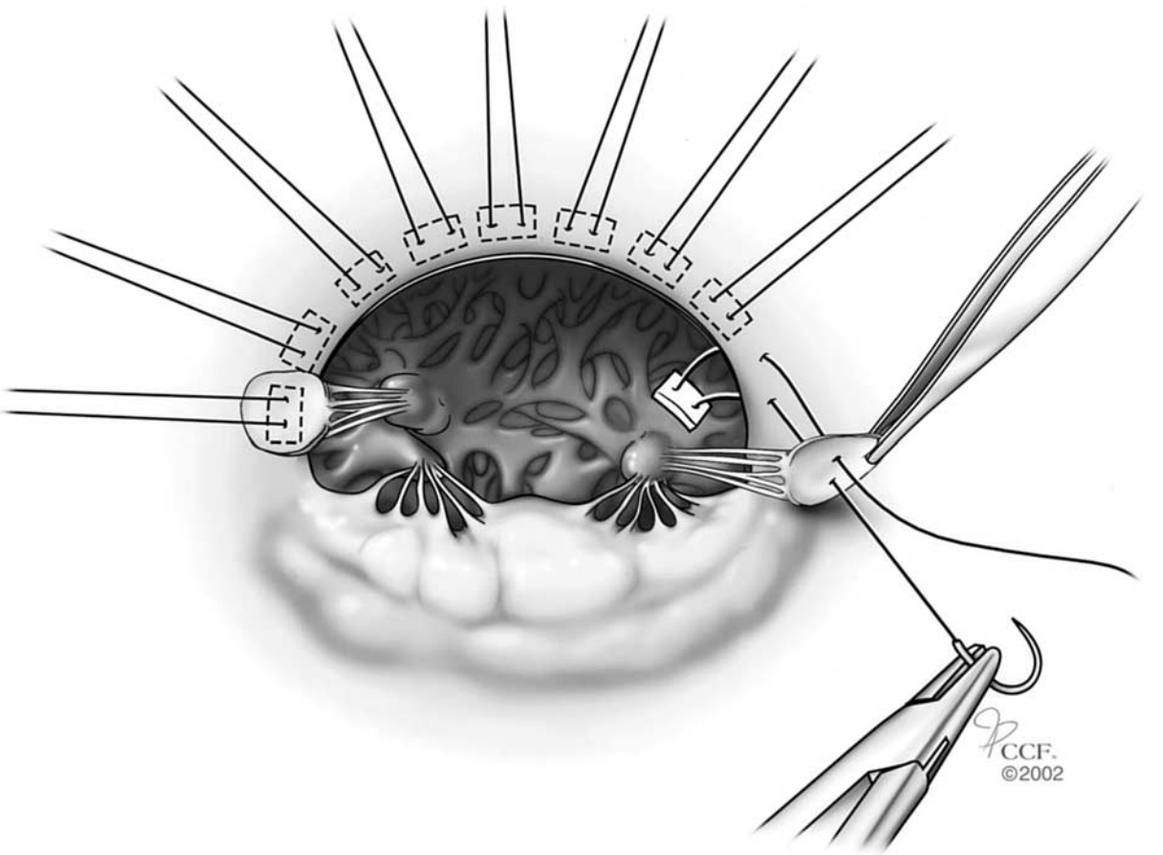
SURGICAL TECHNIQUE
POSTERIOR ANNULAR CALCIFICATION WITH A PLIABLE POSTERIOR LEAFLET



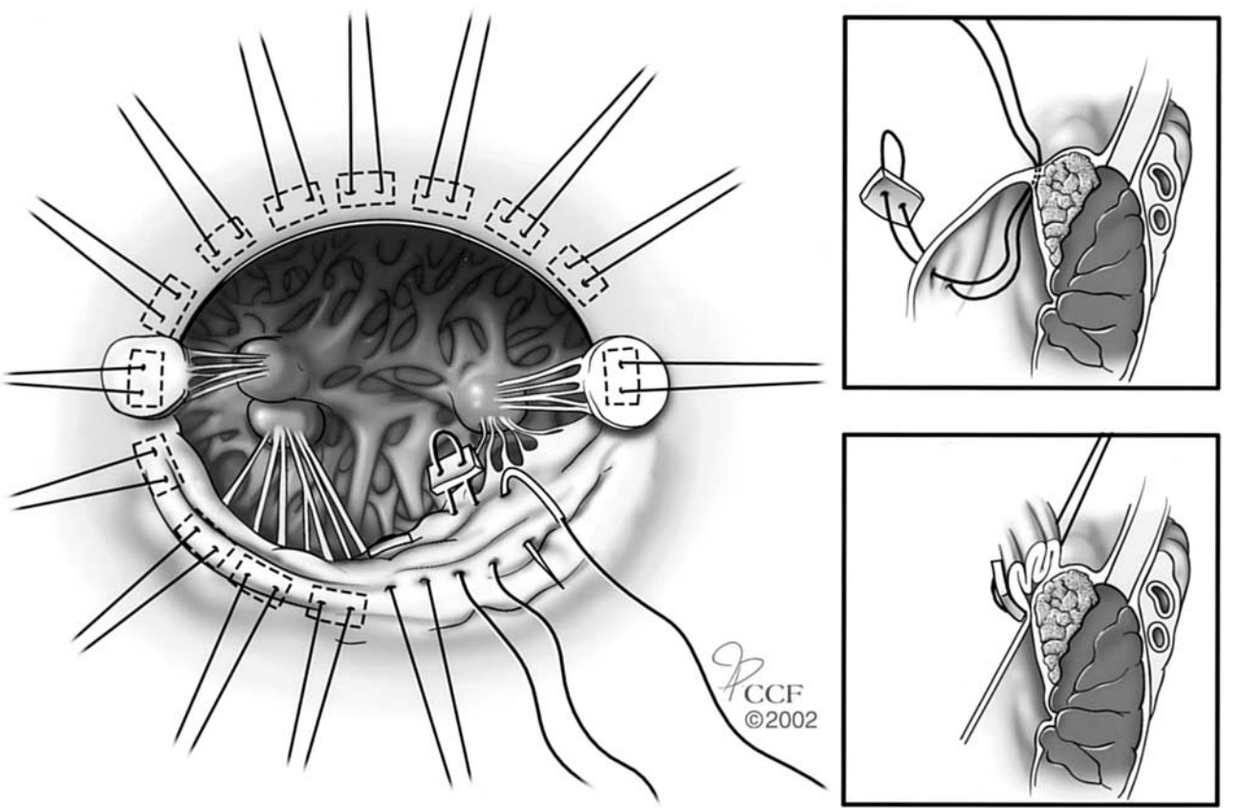
1 The leaflets and annular calcification are inspected. In this case, the calcium is localized to the annulus and both the anterior and posterior leaflet edges are thickened but not calcified (inset).



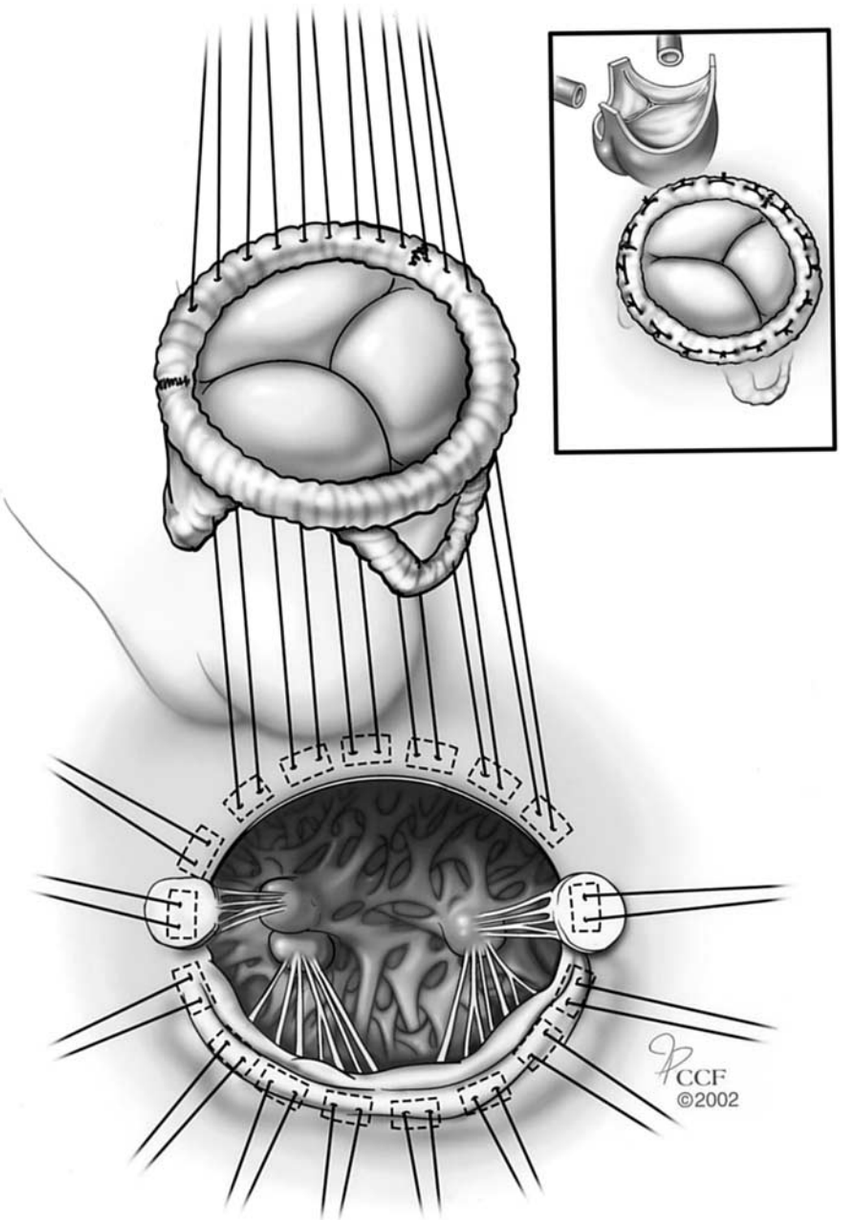
2 The anterior leaflet is detached from the annulus and two small areas or pods of the leaflet are retained that contain the chordae to the anterior and posterior papillary muscles. At this point the size of the orifice is determined and must be capable of fitting at least a 25-mm prosthesis. Plegeted sutures are placed with the pledgets on the ventricular side. Although more difficult to do, this approach has the advantages of being theoretically stronger, reduces the chance of wrapping the sutures around the struts of the biologic valve when the valve is lowered into position, and allows direct tissue to sewing ring apposition without eversion of tissue.[4]



3 The pods of the anterior leaflet are usually secured at the 2-to-3 and 9-to-10 o'clock positions. These sites keep the tissue away from the left ventricular outflow tract and avoids too much heaping of the tissue on top of the posterior leaflet.

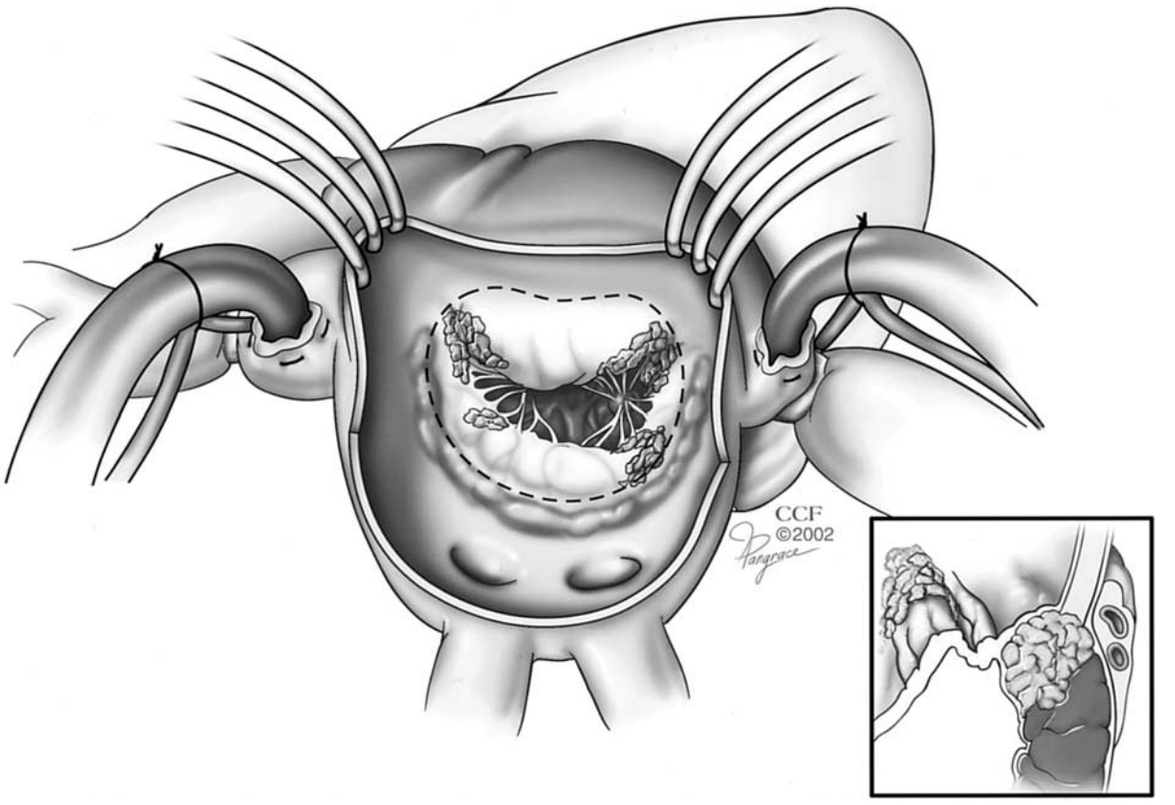


4 Any thickening or calcification of the posterior leaflet must be removed. Sutures are then placed with the needle going first through the free edge of the posterior leaflet and then through the body of the leaflet above the annular calcification. This creates a neoannulus above the calcification. Another technique is to place the sutures from the atrial side under the annular calcification, then through the free edge of the leaflet, and finally through the sewing ring of the valve. I am concerned, however, that this approach increases the risk of circumflex artery injury or kinking and paravalvular leaks.

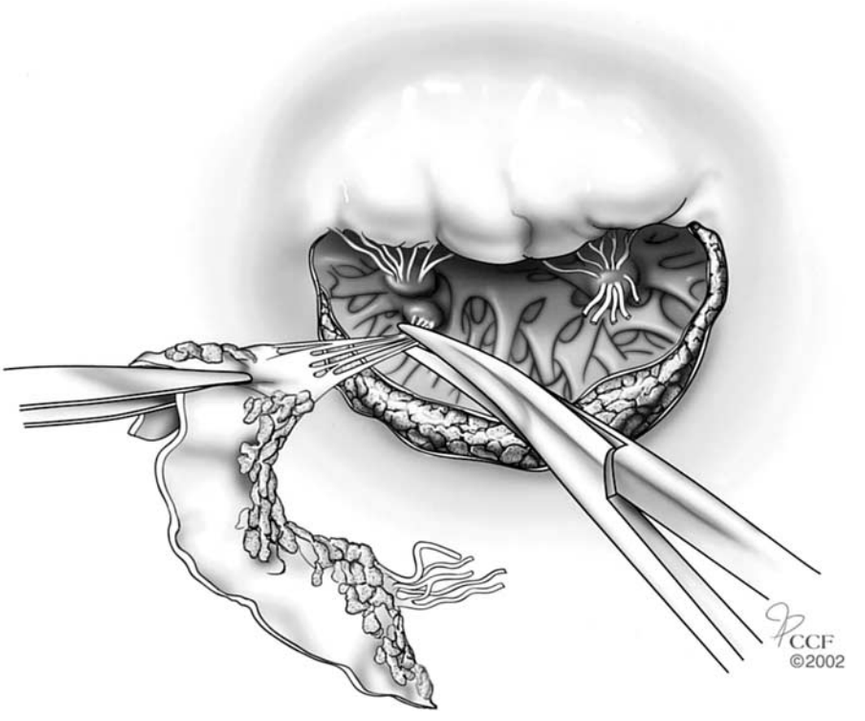


5 The aortic valve is inspected with a mirror and the commissure between the left and non-coronary cusp is identified. This is a good approximation of the middle of the left ventricular outflow tract and the suture beneath this commissure is placed in the middle of the pericardial valve. This orients the valve in such a way as to keep the valve struts out of the middle of the outflow tract.

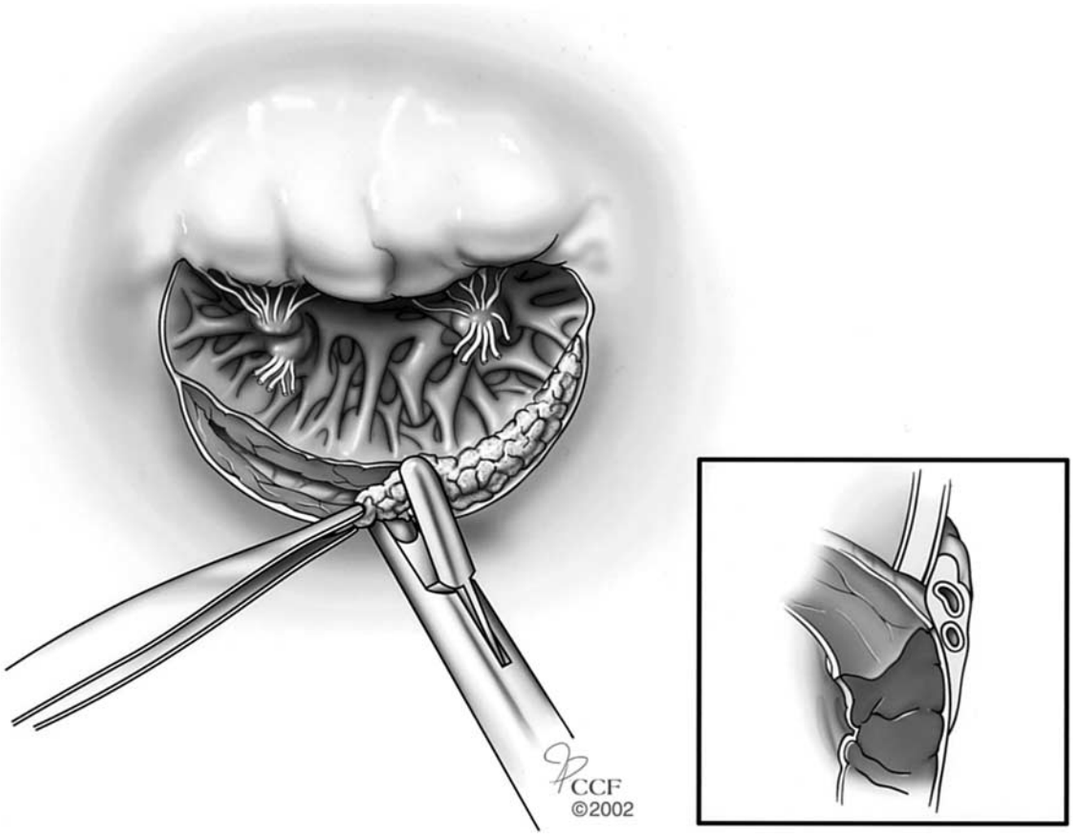
SEVERE VALVE AND ANNULAR CALCIFICATION



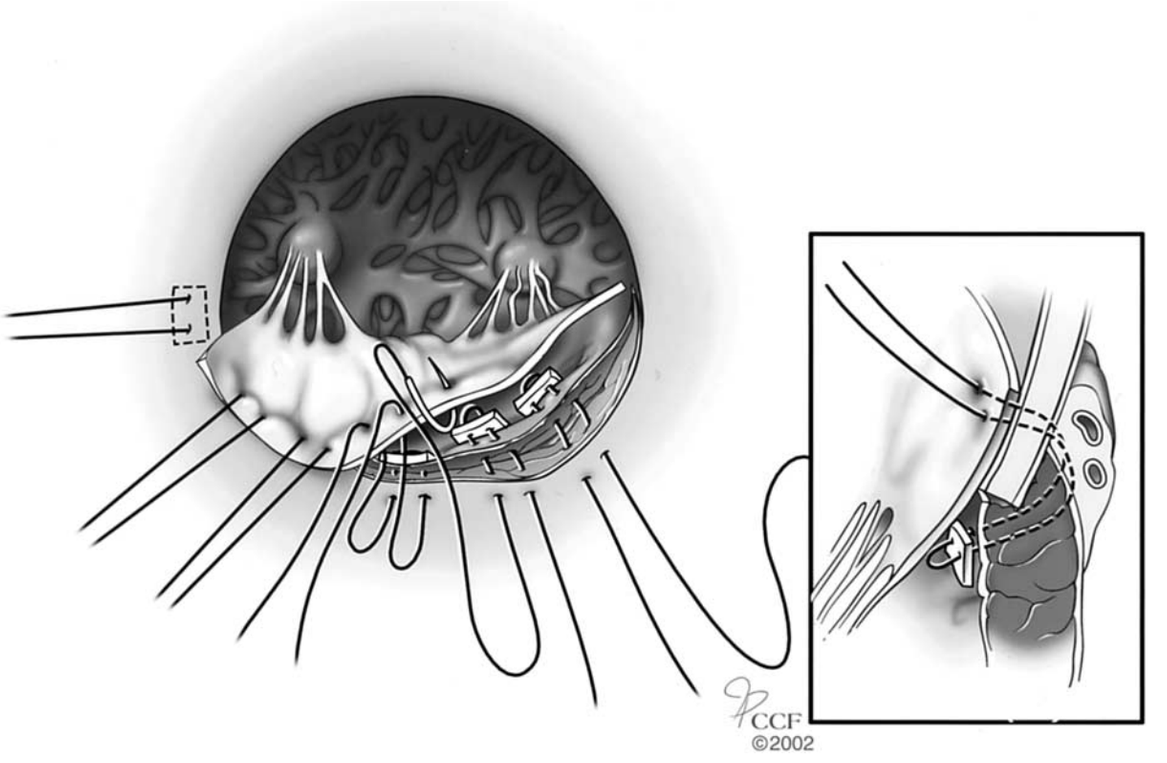
1 In this case, the leaflet tissue is too rigid and the orifice too small to allow direct placement of a valve prosthesis. Note that all or portions of the anterior leaflet are often spared and can be used later to support the posterior annular reconstruction and maintain ventricular annular continuity.



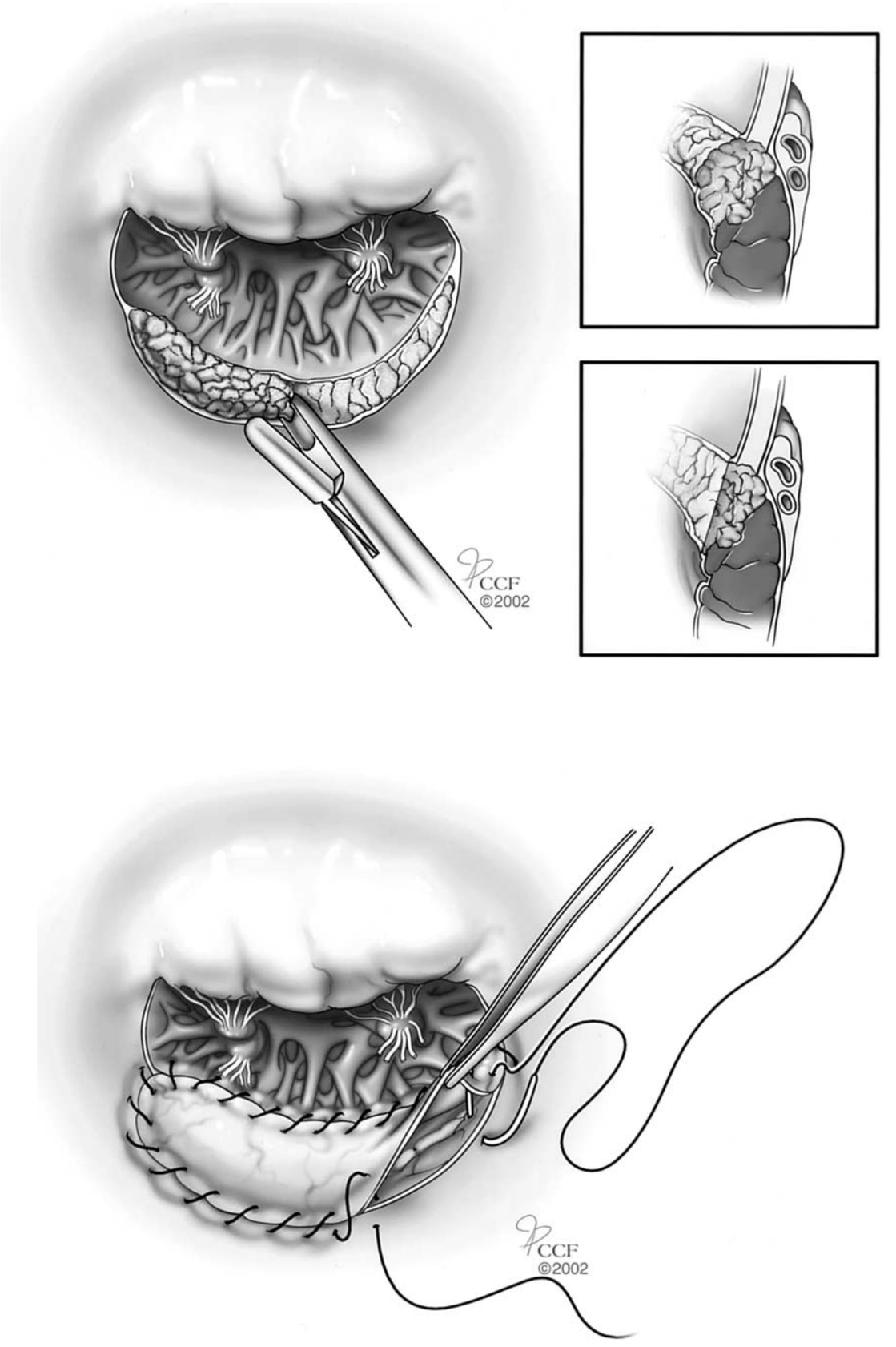
2 Sometimes the posterior leaflet can be detached and used to support the repair, but in this case the valve is too thickened and calcified to be saved. The posterior leaflet is removed, exposing the underlying annular and ventricular calcification.



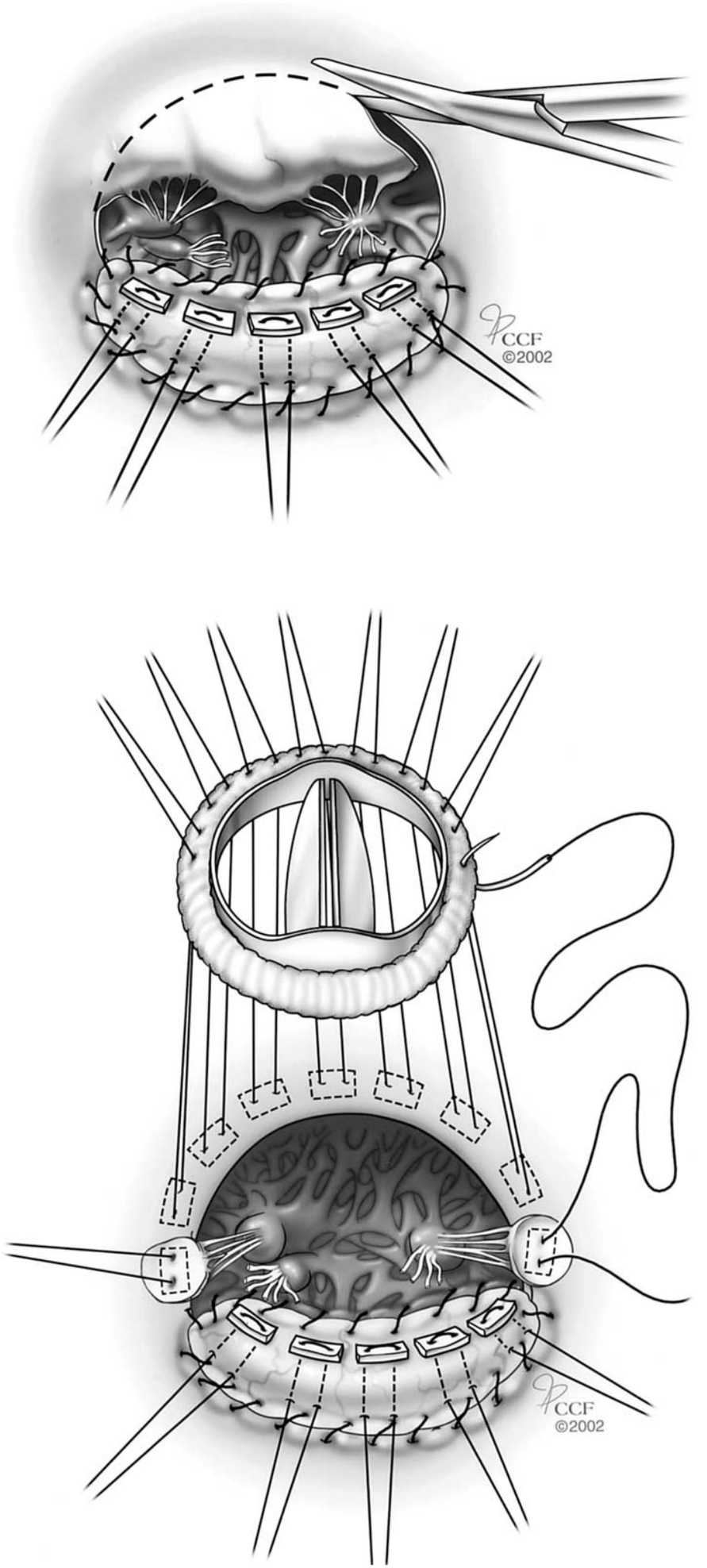
3 If one chooses to completely remove the calcium, care must be taken to avoid injury to the ventricular myocardium and coronary vessels. Often there is a fibrous capsule beneath the calcium and I try to stay above this plane (inset). All calcium fragments must be diligently aspirated from the field.



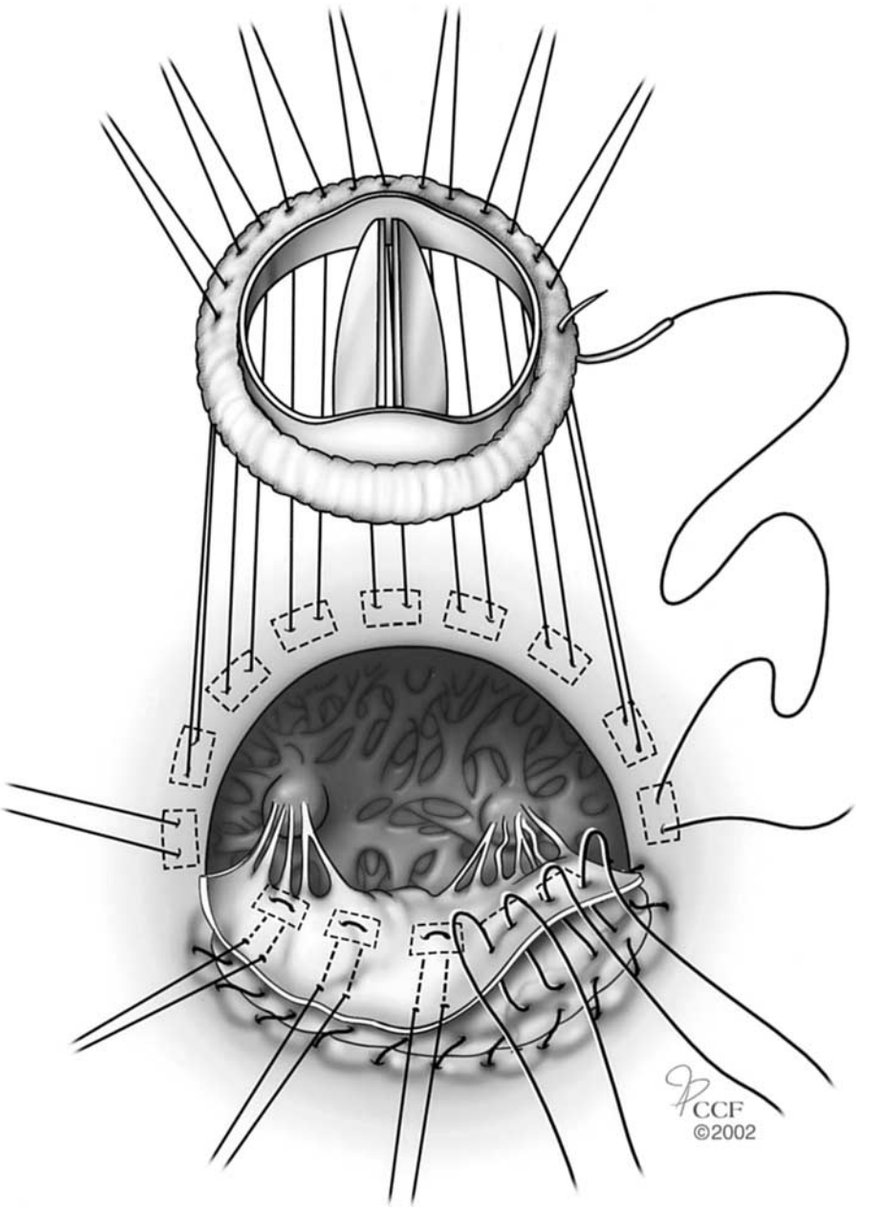
4 In cases where the exposed subannular trough is narrow it is closed directly. Pledgeted mattress sutures pass first through the ventricular myocardium, then through the atrial tissue. The anterior leaflet is brought posterior such that the annular edge of the anterior leaflet is apposed to atrial tissue. This is a modification of the technique described by Casselman.[5] In theory, when the ventricle contracts the anterior leaflet will pull the valve and atrial tissue toward the ventricle and reduce the risk of atrioventricular disruption.



5 For calcification that extends deeply into or completely through the atrioventricular groove, the calcium is reduced in height or "leveled" to facilitate valve insertion. The defect is covered with a bovine pericardial patch using a running prolene suture.[6] Exposure within the depths of the ventricle can be limited and interrupted pledgeted sutures may be easier for patch placement.



6 Valve sutures are placed through the center of the patch.



7 The anterior leaflet is then used to support the patch or can be separated into smaller sections and attached to the annulus, as described above. Bileaflet valves are inserted with the leaflets in an antianatomic position.

COMMENTS

Dealing with mitral annular calcification is a formidable undertaking. Although experts recommend extensive calcium removal, it is my impression that most surgeons attempt to limit the amount of calcium they debride. In most cases, this approach will result in a durable mitral valve replacement. However, in some patients the calcium must be removed; reconstruction of the mitral annulus using one of the techniques described should be safe and reliable. There is very little in the way of published information to support one approach over the other.

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