Undersized Ring Annuloplasty Increases Strain in the Left Ventricle: Finite Element Analysis

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Background: Undersized ring annuloplasty (RA) has been a standard treatment of severe ischemic mitral regurgitation (MR) for many years. Recent studies have identified a high rate of significant MR recurrence after annuloplasty, up to 60% within two years. The causes of this high failure rate are unknown.

Methods: Finite element models were previously created, based on cardiac magnetic resonance images of five sheep with mild to moderate ischemic MR. A 24 mm saddle-shaped rigid annuloplasty ring was modeled and used to simulate virtual RA. [Figure 1]

Figure 1

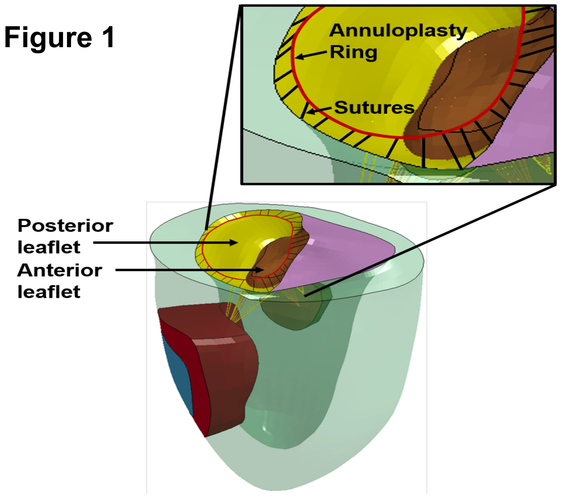
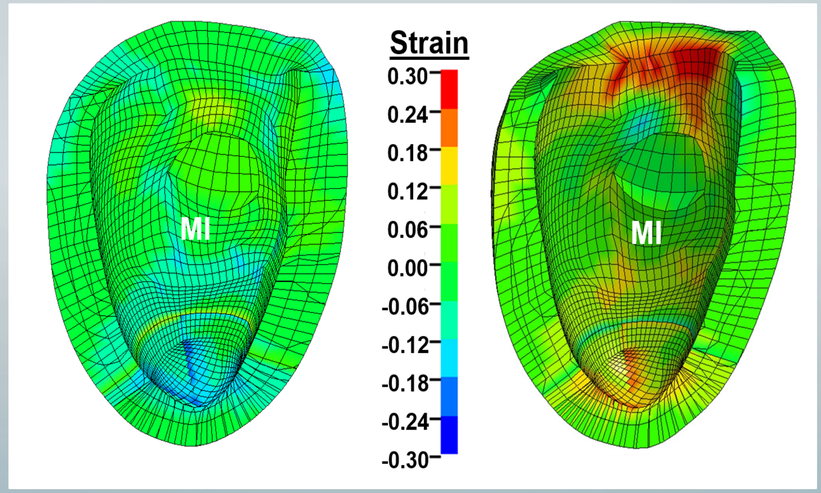


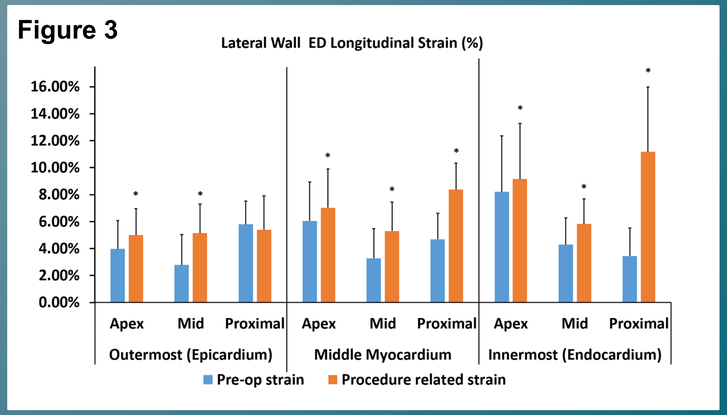
Figure 2: LV strain at End-Diastole



Strain Calculations: Longitudinal and myofiber strains were calculated at end-diastole and end-systole, with pre-operative early diastolic geometry as the reference state. [Figure 2]

Results: Undersized RA significantly increased longitudinal strain at end-diastole in the lateral left ventricular (LV) wall. [Figures 2 & 3] The effect was greatest in the proximal-lateral endocardial surface, where longitudinal strain after RA was approximately triple the pre-operative strain (11.17% ± 2.15% vs. 3.45% ± 0.92%, p=0.0057). There were no significant changes in either strain type at end-systole.

Figure 3



Conclusions: Undersized ring annuloplasty significantly increases strain in the proximal-lateral LV wall. We propose this strain increase as a mechanism for the high failure rate of undersized RA. Future studies will apply this modeling technique to human models of ischemic MR to identify patients in whom repair is likely to succeed.