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Dynamic In Vivo Deformation of the Mitral Valve Leaflet and Annulus In Synchrony

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Objectives:
Mitral valve (MV) repair has increased in popularity to address a variety of valve pathologies. Recent long term studies have identified durability concerns with such techniques, questioning such aggressive surgical practices, and have pointed towards excessive valve stress as a potential cause of failure. Understanding the complex coordinated deformation of the MV leaflet and annulus may help to elucidate repair failure modes resulting from abnormal stresses and help guide future repair techniques.

Method:
Sonocrystal array localization was used to obtain high resolution *in vivo* dynamic spatial information of transducers placed on the MV anterior leaflet surface and MV annulus in an ovine model. Using a finite-element based interpolation method, 2D in-surface Eulerian strain tensors for each time point over a cardiac cycle were calculated. Strain rate was also computed. Using quintic order shape elements to fit annular crystal data, annular stretch and strain rate were interpolated around the annulus for each time point over the same cardiac cycle.

Results:
Leaflet strain and annulus stretch/strain rate values over a cardiac cycle for five animals was calculated. Leaflet strain values reached 12-15% (radial), while annular stretch values ranged from 0.90 to 1.05. Leaflet strain rates reached 100%/s (radial), and annular strain rates reached 750-1000%/s. Both showed highly dynamic responses in synchrony.

Conclusions:
For the first time, high resolution *in vivo* deformation was measured for the MV leaflet and annulus. Results indicate the importance of regional annular deformations and their interplay with anisotropic deformation of the leaflet tissue. Further insight into the dynamic nature of the MV, notably for improved repair strategies, was provided.

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