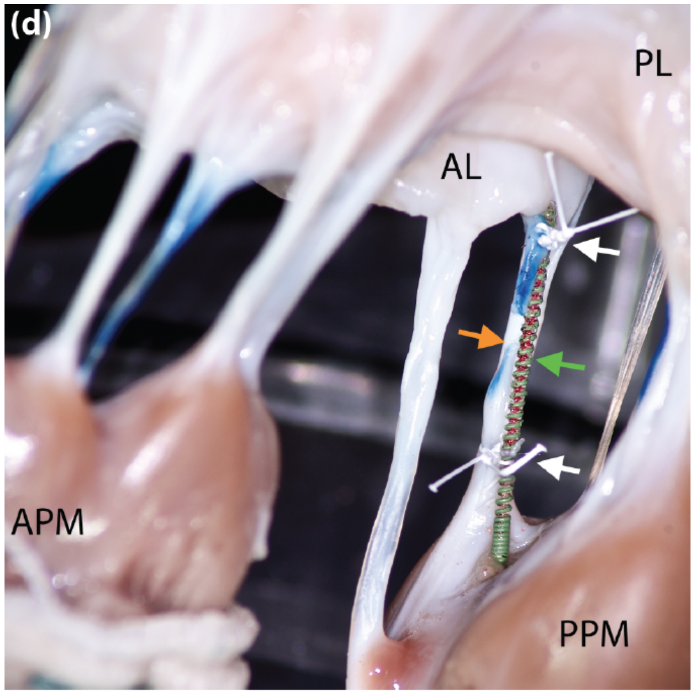
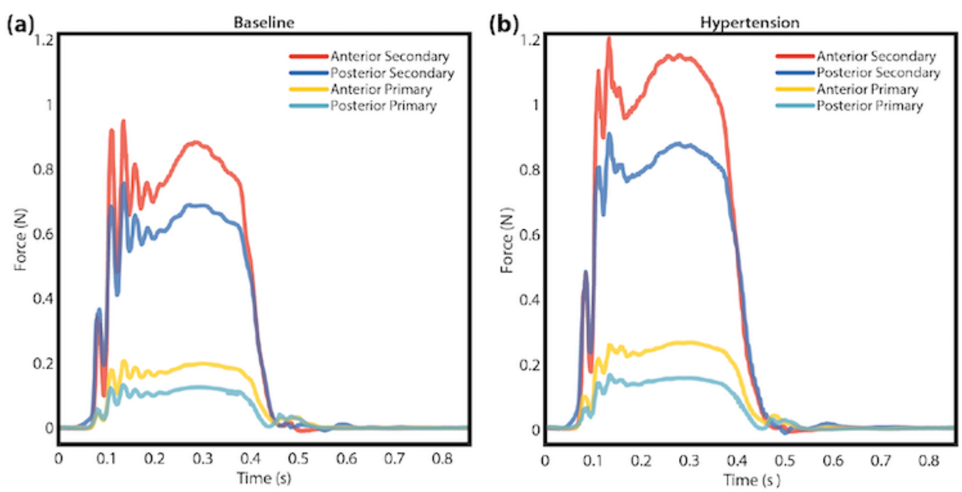
Docket #: S18-298

Compact, optical sensor device to measure forces on mitral valve structures prior to surgical repair or replacement

A team of interdisciplinary researchers at Stanford have developed a small, lightweight optical strain sensor device to sensitively measure forces within the mitral valve apparatus to help determine the appropriate repair technique for patients undergoing valvular surgery for degenerative mitral regurgitation. This force-sensing neochord (FSN) device measures the forces experienced by individual chordae tendineae within the mitral valve using a Fiber Bragg grating (FBG) core encased in a flexible coil sheath. This design mimics the natural shape and movement of natural chordae as much as possible while maintaining a compact physical footprint that minimizes interference with mitral valve leaflet motion. The FSN technology provides an extremely sensitive method for measuring the force generated by mitral valve cordae, either in vitro or in vivo. This could provide a more comprehensive understanding of mitral valve pathology for both research into heart muscle function (including for medical device and drug development) or as a clinical device for cardiovascular surgery and intervention.



Prototype FBG-based force sensing nechord (green arrow) implanted ex vivo via suture (white arrow) to measure the chordae of interest (orange arrow). APM: anteriolateral papillary muscle; PPM: posteriomedial papillary muscle, AL: anterior leaflet.



Force tracing of chordae tendineae at baseline (left) and during hypertensive conditions (right), demonstrating proper function of FBG sensor.

Stage of Research

The inventors have developed a prototype Force Bragg Grating (FBG) sensor device and a 3D printed left heart simulator model. They have demonstrated that the FBG sensors provided high-fidelity force measurements of mitral valve cordae tendineae at a temporal resolution of 1000Hz.

Applications

- **Cardiovascular medical device:**
  - measure forces on delicate and dynamic structure for planning mitral valve repair or replacement
  - could be incorporated into open surgical procedures, catheter delivery devices or implantable devices
- **Cardiovascular research and development** - studies of heart muscle function in basic research or for developing medical devices and cardiovascular drugs

Advantages

- **Compact:**
  - device is smaller and lighter than foil-based strain gauges
  - mimics natural shape and movement of chordae
  - enables more natural measurement without interfering with the overall valve structure and kinematics
- **High-fidelity, sensitive, independent strain measurements:**
  - maximum force sensitivity and reduced noise
  - measures multiple chordae tendineae simultaneously
  - accurately measures the rate of change of force (dF/dt) – a parameter critical to determining likelihood of leaflet rupture
  - unlike marker-based methods, force sensing neochords adapt to heterogeneity and anatomical differences because they are independent of the individual chordae

Publications

- Paulsen, MJ, Bae, JH, Imbrie-Moore, AM, Wang, H, Hironaka, CE, Lucian, HJ, Edwards, BB, Farry, JM, Deschamps, D, Kulkarni, R, Thakore, AD, Williams, KM, Cutkosky, MR, and Woo, YJ. (2018). Abstract 17300: Development and Ex Vivo Validation of Novel Force-Sensing Neo-Tendons for Measuring Chordae

Tendineae Tension in the Mitral Valve Apparatus Using Optical Fibers With Embedded Bragg Gratings. *Circulation*, 138, Suppl 1: A17300.

Patents

- Published Application: 20210338364

Innovators

- Michael Paulsen
- Joseph Woo
- Mark Cutkosky
- Jung Hwa Bae
- Annabel Imbrie-Moore

Licensing Contact

Seth Rodgers

Licensing Manager, Life Sciences

Email