Abstract
Skin is a remarkable thin membrane with nonlinear and anisotropic properties that protects us from the outside world. Skin is a living tissue; its ability to adapt to extreme conditions has led to tissue expansion, a widely used technique in reconstructive surgery that grows skin in vivo to correct large defects. Tissue adaptation can be characterized kinematically by splitting the deformation gradient into growth and elastic contributions within a continuum mechanics framework. The growth component is a function of strain, when stretched beyond its physiological limit, new tissue will form. This talk will present how computational simulations have showed good qualitative agreement to different baseline device geometries and patient-specific scenarios, showing promise for aiding pre-operative planning while also exploring basic scientific questions. In collaboration with Dr. Arun K. Gosain, from the Lurie Children’s Hospital in Chicago, we have also conducted experiments to characterize the kinematics of tissue expansion in a porcine model in order to inform and calibrate the mathematical model (Fig. 1). The experimental design that I propose is innovative and creative, using two novel computational tools, multi-view stereo and isogeometric analysis, and allowing an inexpensive and flexible setup. We show for the first time the spatial variations of tissue prestrain, expansion-induced deformation and resulting tissue growth. Our findings support the hypothesis that stretches beyond the physiological limit regulate the growth of new skin.

Fig. 1. Mechanical characterization of skin expansion. Multi-view stereo makes it possible to reconstruct a 3D geometric model out of uncalibrated photographs. Then, using a continuum mechanics framework, the theory of finite growth, and isogeometric analysis we quantify regional variations of tissue deformations.

Biographical sketch
Adrian Buganza-Tepole is a Ph.D. Candidate in Mechanical Engineering at Stanford University. He obtained his bachelor’s degree in Mechatronics Engineering from Universidad Panamericana in Mexico City, and his master’s degree in mechanical engineering from Stanford University with an emphasis in biomechanics and computational mechanics. He is a recipient of the Claudio X. González Fellowship and a scholarship from the Mexican National Science Council. He has also received the prestigious Stanford Graduate Fellowship in Science and Engineering (SGF) and most recently awarded Stanford’s Vice Provost for Graduate Education’s Diversifying Academia Recruiting Excellence fellowship (DARE).

Adrian’s research focuses on the interplay between mechanics and biology in an attempt to improve current clinical diagnostics and interventional tools. Utilizing computational methods, simulations, and experimentation, he seeks to understand the fundamental mechanisms of tissue mechanics and adaptation. By implementing the classical theories of mechanics and systems biology together with computational tools, such as finite elements and isogeometric analysis, he has modeled skin growth during tissue expansion, a common technique in reconstructive surgery used to create skin flaps. In collaboration with reconstructive surgeons, Adrian has performed animal experiments to inform and validate these models by measuring tissue mechanical properties, quantifying deformations, and performing immunohistochemical analysis. His additional work in the fields of wound healing and sleep apnea complements his ultimate research objectives of using computational approaches to impact and revolutionize healthcare.