Submucosa is the load-bearing structure of distal colon and rectum

Authors

*S. Siri[1], F. Maier[2], S. Santos[2], D.M. Pierce[2,1], B. Feng[1]

[1]Department of Biomedical Engineering, University of Connecticut, CT 06269

[2]Department of Mechanical Engineering, University of Connecticut, CT 06269

Disclosures

S. Siri: **None**, F. Maier: **None**, S. Santos: **None**, D.M. Pierce: **None** ,B. Feng: **None**

Abstract

Visceral pain from distal colon and rectum (colorectum) has a unique biomechanical aspect: it is mechanical colorectal distension/stretch — not heating, pinching, or cutting the colorectum — that effectively evokes the perception of pain. Our recent study reveals significant differences in local biomechanical properties at different regions along the longitudinal colorectum. The current study focuses on the layered structure of the colorectum across the wall thickness and determines the biomechanical properties of layer-separated colorectal tissue. We harvested the distal 30 mm of the colorectum from mice and performed fine dissection to separate into inner and outer composite layers from the interstitial space under the submucosa. The inner composite consists of the mucosa and submucosa while the outer composite includes the muscular layers and serosa. We then divided each composite longitudinally into three 10-mm-long segments (colonic, intermediate, and rectal) and conducted biaxial mechanical stretch tests and opening-angle measurements for each tissue segment. In addition, we quantified the morphology and geometry of the rich collagen network in the submucosal layer by nonlinear imaging via second harmonic generation (SHG). Our results reveal signficantly higher stiffness of the inner composite than the outer composite in both axial and circumferential directions. The tissue is anisotropic at all regions of the colorectum with higher stiffness in the axial direction than in the circumferential direction, and tissue anisotropy is more pronounced in the inner composite than in the outer one. The stiffness of the inner composite in the axial direction is about twice that in the circumferential direction, consistent with the orientations of collagen fibers in the submucosa approximately ± 30 degrees to the axial direction. Strikingly, the axial stress - stretch relations are comparable across all three regions in the inner composite (colonic, intermediate and rectal) despite their significant differences in thickness, which is likely due to the comparable thickness and morphology of network of collagen fibers throughout the longitudinal directions in the submucosa. These biomechanical and morphological results strongly indicate the submucosa as the load-bearing structure of the colorecum. This, in turn, implies nociceptive roles for the colorectal afferent endings in the submucosa that likely encode tissue-injurious mechanical distension/stretch to inform the central nervous system.

References

[1] Siri, S., Maier, F., Chen, L., Santos, S., Pierce, D.M., and Feng, B. (2019). Differential biomechanical properties of mouse distal colon and rectum innervated by the splanchnic and pelvic afferents. *AJP-Gastrointestinal and Liver Physiology*.

[2] Siri, S., Maier, F., Pierce, D.M., and Feng, B. (2018). The biomechanics of distal colon and rectal wall and its implication in visceral sensation and hypersensitivity. *17th World Congress on Pain (International Association for the Study of Pain)*.

[3] Siri, S., Maier, F., Pierce, D.M., and Feng, B. (2019). Determining the biomechanics of layer-separated mouse colorectum using biaxial tensile stretch. In: *Proceedings of the Biomedical Engineering Society 2019 Annual Fall Meeting. Philadelphia*.

[4] Feng, B., Maier, F., Siri, S., and Pierce, D.M. (2019). Quantifying the collagen-network morphology in mouse distal colon and rectum. In: *Proceedings of the Biomedical Engineering Society 2019 Annual Fall Meeting. Philadelphia*.