FROM ANIMAL MODEL TO HUMAN STUDY: A MECHANICAL AND STRUCTURAL ANALYSIS OF THE STOMACH

Clarissa Holzer (1), Anna Pukaluk (1), Christian Viertler (2), Peter Regitnig (2), Alexander W. Caulk (3), Matthew Eschbach (3), Gerhard A. Holzapfel (1,4)

1. Institute of Biomechanics, Graz University of Technology, Austria, 2. Diagnostic and Research Institute of Pathology, Medical University of Graz, Austria, 3. Surgical Innovations, Medtronic, North Haven, CT, USA, 4. Department of Structural Engineering, NTNU, Trondheim, Norway

Introduction

Animal models are widely used in comparative medicine to substitute human studies. In gastroenterology, the pig is one of the most common models of the human digestive system due to its similar functionality [1,2]. Although this practice has been widely accepted, the question remains: *Does porcine gastric tissue properly reflect the biomechanics of the human stomach?* This study aims to answer this question through systematic mechanical testing and histology.

Methods

A region- and layer-specific comparative study between porcine and human gastric tissue was performed. While the porcine specimen was obtained from a local slaughterhouse, the human samples came from remnants after sleeve gastrectomy. To ensure the inactivation of smooth muscle cells, all samples were frozen at -20°C within 2 hours of procurement, thawed, and tested submerged in cardioplegic solution. Radial compression, shear, and planar biaxial extension tests with different loading protocols were conducted to analyze the dissimilarity of the directional, layer, and region-dependent material responses. The mechanical testing was complemented by a thorough microstructural analysis of the tissue through histology.

Results

The quasi-static tests revealed a clear region- and layer-dependent anisotropy for both species, which corresponds to the underlying tissue composition. The pronounced hysteresis formation implied strong viscoelastic properties of the gastric tissue, which were confirmed by stress-relaxation measurements. Although porcine and human tissue exhibited these properties, they were significantly dissimilar in other aspects. Human tissues not only differed in structure but also behaved drastically softer and showed differing regional trends and resilience to certain loading modes, see Figure 1.

Discussion

Since both wall composition and mechanical material properties of the stomach differed significantly between porcine and human gastric tissue, the present study highlights important open questions on the application of porcine animal models in the fields of gastroenterology and bariatric surgery. Although the digestive systems of both species may be comparable, animal models should be used with caution for biomedical studies. They can serve as useful preliminary studies to test study methodology, but should not be taken as a substitute for a human clinical study. The knowledge gained about the different biomechanical properties of porcine and human gastric tissue should be considered and used in the future evaluation of suitable constitutive models.

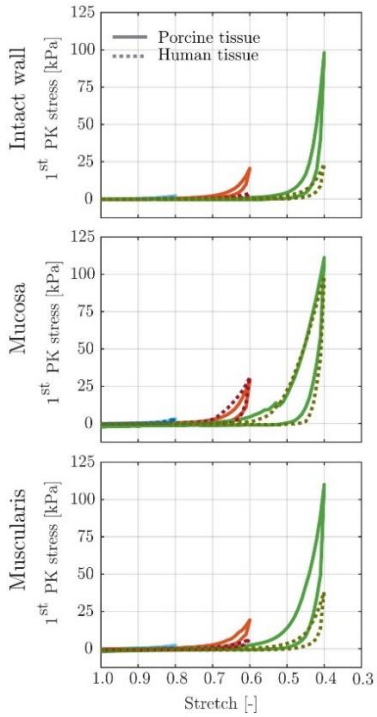

Figure 1: Stress vs stretch behavior obtained from radial compression tests of the porcine (solid line) and human (dashed line) stomach tissues. The intact wall (top) and its dissected layers, mucosa (middle), and muscularis (bottom) are shown compressed to stretches of 0.8 (blue), 0.6 (red), and 0.4 (green). The regional and layer-specific differences are especially pronounced within the intact wall and the muscularis.

References

1. Rose et al, Front Vet Sci, 9, 2022
2. Gonzales et al, Transl Res, 166:12-27, 2015

Acknowledgments

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