UNIVERSITÀ DEGLI STUDI DELL'AQUILA
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International Research Center on
MATHEMATICS AND MECHANICS
OF COMPLEX SYSTEMS

Gerhard Holzapfel is currently Professor of Biomechanics and Head of the Institute of Biomechanics at Graz University of Technology (TUG) (Austria) as well as Adjunct Professor at the Norwegian University of Science and Technology (Trondheim, Norway) and Visiting Professor at the University of Glasgow (Scotland). He received his Ph.D. in Mechanical Engineering from TUG in 1990, after which he received an Erwin-Schrödinger Scholarship for foreign countries to be a Visiting Scholar at Stanford University from 1993 to 1995. He obtained his Habilitation at TU Wien in 1996 and received a START-Award in 1997. In 1998, he became Associate Professor and Head of the research group "Computational Biomechanics" at TUG, a position which he held until 2004. From 2004 to 2007, before joining TUG as a professor, he was Professor of Biomechanics at the Royal Institute of Technology (KTH).

Gerhard Holzapfel's main research interests lie on experimental and computational biomechanics and mechanobiology as well as nonlinear continuum mechanics. In terms of biomechanics, he has worked on soft biological tissues, the cardiovascular system including blood vessels in health and disease, therapeutic interventions such as balloon angioplasty and stent implantation, polarized light and second-harmonic imaging microscopy, magnetic resonance imaging and medical image processing. In terms of nonlinear continuum mechanics, his work includes constitutive (multi-scale) modeling of solids at finite strains such as cross-linked actin networks, growth and remodeling, nonlinear finite element methods, fracture and material failure.

His contributions to the mechanical sciences are outstanding and will leave a permanent impression on contemporary biomechanics.

Gerhard Holzapfel has contributed to more than 20 books, including a graduate textbook entitled "Nonlinear Solid Mechanics. A Continuum Approach for Engineering" (John Wiley & Sons), and co-edited seven books. He has published more than 250 peer-reviewed journal articles and is the co-founder and co-editor of the International Journal "Biomechanics and Modeling in Mechanobiology" (Springer-Verlag, Berlin, Heidelberg).

The selection committee of the Beltrami Prize considered his contributions to biomechanics to be of particular importance, presented in the paper Holzapfel, Gerhard A., Thomas C. Gasser, and Ray W. Ogden "A new constitutive framework for arterial wall mechanics and a comparative study of material models", published in the Journal of Elasticity and the Physical Science of Solids in 2000. In this paper a very original and innovative constitutive law has been introduced that aims to describe the mechanical response of arterial tissue. The constitutive relationship postulated for the employed continuum model is based on a detailed representation of the arterial micro-structure. In fact, such a relationship is derived by modeling the arterial walls as thick nonlinear-elastic circular cylindrical tubes, which in turn consist of two different layers. These layers represent the media and the adventitia, namely the mechanically most relevant functional structures in healthy arterial tissues. The proposed model treats both layers as fiber-reinforced materials, where fibers represent the collagenous component of the tissue and are assumed to be arranged symmetrically with respect to the cylinder axis. Due to this symmetry, the postulated constitutive law is chosen to be orthotropic for each layer. In order to make the model biomechanically well-grounded and establish a strong relationship with experimental and clinical evidence, a statistical analysis of histological sections for both the media and the adventitia is used to postulate the modeling of fiber orientations in the introduced layers. It has been shown that just three material parameters for each layer are sufficient to capture the observed mechanical behavior, and an excellent agreement with experimental data for the response of an artery under combined axial extension, inflation and torsion is achieved. In addition, the model is adjusted to account for the peculiar and biologically relevant residual stress observed in vitro. This is accomplished by assuming that the postulated unstressed configuration of the continuum micro-structured composite material corresponds to its configuration when the tube is unfolded. The residual stress on the predicted deformation pattern of the deformed arterial wall in the physiological state, which is extremely relevant, is also examined.

The theoretical efforts are completed by fitting the data available from experimental evidence collected for arteries, and model predictions are verified for all combined loadings considered. The article concludes with a discussion of how the new model has been conceived to circumvent many of the mechanical, mathematical, and computational challenges that arose in previous literature dealing with phenomenological arterial models.

For the remarkable impact of his work on the scientific community working in biomechanics, the Scientific Committee of the Beltrami Prize for the Mathematical and Mechanical Sciences is honored to propose Gerhard Holzapfel as recipient of the 2020 edition of the prize.