Peter M Pinsky

PROFESSOR OF MECHANICAL ENGINEERING AND, BY COURTESY, OF CIVIL ENGINEERING

PRINT PROFILE

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BIO

TEACHING

PUBLICATIONS

Bio

Academic Appointments

MECHANICAL ENGINEERING

BIO-X

Honors & Awards

Professional Education

CONTACT

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2014-15 Courses

FINITE ELEMENT ANALYSIS
ME 335A (Aut)

FINITE ELEMENT ANALYSIS
ME 335B (Win)

FINITE ELEMENT ANALYSIS
ME 335C (Spr)

INTRODUCTION TO COMPUTATIONAL MECHANICS
ME 332 (Sum)

INDEPENDENT STUDIES (12)

ADVANCED READING AND RESEARCH
SCCM 499 (Win, Sum)

ENGINEERING PROBLEMS
ME 391 (Aut, Win, Spr, Sum)

ENGINEERING PROBLEMS AND EXPERIMENTAL INVESTIGATION
ME 191 (Aut, Win, Spr, Sum)

EXPERIMENTAL INVESTIGATION OF ENGINEERING PROBLEMS
ME 392 (Aut, Win, Spr, Sum)

GRADUATE INDEPENDENT STUDY
MATSCI 399 (Aut, Win, Spr, Sum)

HONORS RESEARCH
ME 191H (Aut, Win, Spr, Sum)

MASTER'S RESEARCH
MATSCI 200 (Aut, Win, Spr, Sum)

PH.D. RESEARCH
MATSCI 300 (Aut, Win, Spr, Sum)

PH.D. TEACHING EXPERIENCE
ME 491 (Aut, Win, Spr, Sum)

PRACTICAL TRAINING
MATSCI 299 (Aut, Win, Spr, Sum)

PRACTICAL TRAINING
ME 299A (Aut, Win, Spr, Sum)

PRACTICAL TRAINING
ME 299B (Aut, Win, Spr, Sum)

PRIOR YEAR COURSES

2013-14 Courses

FINITE ELEMENT ANALYSIS
ME 335A (Win)

FINITE ELEMENT ANALYSIS
ME 335C (Sum)

2012-13 Courses

FINITE ELEMENT ANALYSIS
ME 335A (Win)

FINITE ELEMENT ANALYSIS
ME 335B (Spr)
FINITE ELEMENT ANALYSIS
ME 335C (Sum)
MECHANICS OF MATERIALS
ME 80 (Aut)

2011-12 Courses

FINITE ELEMENT ANALYSIS
ME 335A (Win)
FINITE ELEMENT ANALYSIS
ME 335B (Spr)
SEMINAR IN SOLID MECHANICS
ME 395 (Aut, Win, Spr)

All Publications

A structural model for the in vivo human cornea including collagen-swelling interaction. *Journal of the Royal Society, Interface / the Royal Society* Cheng, X., Petsche, S. J., Pinsky, P. M. 2015; 12 (109)

Abstract

A structural model of the in vivo cornea, which accounts for tissue swelling behaviour, for the three-dimensional organization of stromal fibres and for collagen-swelling interaction, is proposed. Modelled as a binary electrolyte gel in thermodynamic equilibrium, the stromal electrostatic free energy is based on the mean-field approximation. To account for active endothelial ionic transport in the in vivo cornea, which modulates osmotic pressure and hydration, stromal mobile ions are shown to satisfy a modified Boltzmann distribution. The elasticity of the stromal collagen network is modelled based on three-dimensional collagen orientation probability distributions for every point in the stroma obtained by synthesizing X-ray diffraction data for azimuthal angle distributions and second harmonic-generated image processing for inclination angle distributions. The model is implemented in a finite-element framework and employed to predict free and confined swelling of stroma in an ionic bath. For the in vivo cornea, the model is used to predict corneal swelling due to increasing intraocular pressure (IOP) and is adapted to model swelling in Fuchs' corneal dystrophy. The biomechanical response of the in vivo cornea to a typical LASIK surgery for myopia is analysed, including tissue fluid pressure and swelling responses. The model provides a new interpretation of the corneal active hydration control (pump-leak) mechanism based on osmotic pressure modulation. The results also illustrate the structural necessity of fibre inclination in stabilizing the corneal refractive surface with respect to changes in tissue hydration and IOP.

View details for DOI 10.1098/RSIF.2015.0241

View details for PUBMEDID 26156299

Three-Dimensional Modeling of Metabolic Species Transport in the Cornea With a Hydrogel Intrastromal Inlay *INVESTIGATIVE OPHTHALMOLOGY & VISUAL SCIENCE* Pinsky, P. M. 2014; 55 (5): 3093-3106

Abstract

Intrastromal inlays for refractive correction of presbyopia are being adopted into clinical practice. An important concern is the effect of the inlay on the long-term health of the cornea due to disturbances in the concentration profiles of metabolic species. A three-dimensional metabolic model for the cornea is employed to investigate oxygen, glucose, and lactate ion transport in the cornea and to estimate changes in species concentrations induced by the introduction of a hydrogel inlay.A reaction-diffusion metabolic model, appropriate for highly oxygen-permeable hydrogel inlays, is used to describe cellular consumption of oxygen and glucose and production of lactic acid. A three-layer corneal geometry (epithelium, stroma, endothelium) is employed with a hydrogel inlay placed under a lamellar flap. The model is solved numerically by the finite element method.For a commercially available hydrogel material with a relative inlay diffusivity of 43.5%,

maximum glucose depletion and lactate ion accumulation occur anterior to the inlay and both are less than 3%. Below 20% relative diffusivity, glucose depletion and lactate ion accumulation increase exponentially. Glucose depletion increases slightly with increasing depth of inlay placement.The flux of metabolic species is modified by an inlay, depending on the inlay relative diffusivity. For commercially available hydrogel materials and a typical inlay design, predicted changes in species concentrations are small when compared to the variation of concentrations across the normal cornea. In general, glucose depletion and lactate ion accumulation are highly sensitive to inlay diffusivity and somewhat insensitive to inlay depth.

View details for DOI 10.1167/IOVS.13-13844

View details for WEB OF SCIENCE ID 000339484800037

View details for PUBMEDID 24833750

The role of 3-D collagen organization in stromal elasticity: a model based on X-ray diffraction data and second harmonic-generated images. *Biomechanics and modeling in mechanobiology* Petsche, S. J., Pinsky, P. M. 2013; 12 (6): 1101-1113

Abstract

Examining the cross-section of the human cornea with second harmonic-generated (SHG) imaging shows that many lamellae do not lie parallel to the cornea's anterior surface but have inclined trajectories that take them through the corneal thickness with a depth-dependent distribution. A continuum mechanics-based model of stromal elasticity is developed based on orientation information extracted and synthesized from both X-ray scattering studies and SHG imaging. The model describes the effects of inclined lamella orientation by introducing a probability function that varies with depth through the stroma, which characterizes the range and distribution of lamellae at inclined angles. When combined with the preferred lamellar orientations found from X-ray scattering experiments, a fully 3-D representation of lamella orientation is achieved. Stromal elasticity is calculated by a weighted average of individual lamella properties based on the spatially varying 3-D orientation distribution. The model is calibrated with in vitro torsional shear experiments and in vivo indentation data and then validated with an in vitro inflation study. A quantitative explanation of the experimentally measured depth dependence of mechanical properties emerges from the model. The significance of the 3-D lamella orientation in the mechanics of the human cornea is demonstrated by investigating and contrasting the effects of previous modeling assumptions made on lamella orientation.

View details for DOI 10.1007/S10237-012-0466-8

View details for PUBMEDID 23288406

The role of 3-D collagen organization in stromal elasticity: a model based on X-ray diffraction data and second harmonic-generated images *BIOMECHANICS AND MODELING IN MECHANOBIOLOGY* Petsche, S. J., Pinsky, P. M. 2013; 12 (6): 1101-1113

View details for DOI 10.1007/S10237-012-0466-8

View details for WEB OF SCIENCE ID 000325815300003

Mechanisms of self-organization for the collagen fibril lattice in the human cornea *JOURNAL OF THE ROYAL SOCIETY INTERFACE* Cheng, X., Pinsky, P. M. 2013; 10 (87)

Abstract

The transparency of the human cornea depends on the regular lattice arrangement of the collagen fibrils and on the maintenance of an optimal hydration-the achievement of both depends on the presence of stromal proteoglycans (PGs) and their linear sidechains of negatively charged glycosaminoglycans (GAGs). Although the GAGs produce osmotic pressure by the Donnan effect, the means by which they exert positional control of the lattice is less clear. In this study, a theoretical model based on equilibrium thermodynamics is used to describe restoring force mechanisms that may control and maintain the fibril lattice and underlie corneal transparency. Electrostatic-based restoring

forces that result from local charge density changes induced by fibril motion, and entropic elastic restoring forces that arise from duplexed GAG structures that bridge neighbouring fibrils, are described. The model allows for the possibility that fibrils have a GAG-dense coating that adds an additional fibril force mechanism preventing fibril aggregation. Swelling pressure predictions are used to validate the model with results showing excellent agreement with experimental data over a range of hydration from 30 to 200% of normal. The model suggests that the electrostatic restoring force is dominant, with the entropic forces from GAG duplexes being an order or more smaller. The effect of a random GAG organization, as observed in recent imaging, is considered in a dynamic model of the lattice that incorporates randomness in both the spatial distribution of GAG charge and the topology of the GAG duplexes. A striking result is that the electrostatic restoring forces alone are able to reproduce the image-based lattice distribution function for the human cornea, and thus dynamically maintain the short-range order of the lattice.

View details for DOI 10.1098/RSIF.2013.0512

View details for WEB OF SCIENCE ID 000330298300015

View details for PUBMEDID 23904589

Abstract

DOI 10.1121/1.4806258

PUBMEDID 23655592

Three-dimensional distribution of transverse collagen fibers in the anterior human corneal stroma. *Investigative ophthalmology & visual science* Winkler, M., Shoa, G., Xie, Y., Petsche, S. J., Pinsky, P. M., Juhasz, T., Brown, D. J., Jester, J. V. 2013; 54 (12): 7293-7301

Abstract

Recent investigations of human corneal structure and biomechanics have shown that stromal collagen fibers (lamellae) are organized into a complex, highly intertwined three-dimensional meshwork of transverse oriented fibers that increases stromal stiffness and controls corneal shape. The purpose of this study was to characterize the three-dimensional distribution of transverse collagen fibers along the major meridians of the cornea using an automated method to rapidly quantify the collagen fibers' angular orientation.Three eyes from three donors were perfusion-fixed under pressure, excised, and cut into four quadrants. Quadrants were physically sectioned using a vibratome and scanned using nonlinear optical high-resolution macroscopy. Planes were analyzed numerically using software to identify collagen fiber angles relative to the corneal surface, stromal depth, and radial position within the anterior 250 μm of the stroma.The range of fiber angles and the fiber percentage having an angular displacement greater than ±3.5° relative to the corneal surface ("transverse fibers") was highest in the anterior stroma and decreased with depth. Numerical analysis showed no significant differences in fiber angles and transverse fibers between quadrants, meridians, and radial position.These results match our previous observation of a depth-dependent gradient in stromal collagen

interconnectivity in the central cornea, and show that this gradient extends from the central cornea to the limbus. The lack of a preferred distribution of angled fibers with regard to corneal quadrant or radial position likely serves to evenly distribute loads and to avoid the formation of areas of stress concentration.

View details for DOI 10.1167/IOVS.13-13150

View details for PUBMEDID 24114547

Abstract

DOI 10.1167/IOVS.11-8611

WEB OF SCIENCE ID 000302788600046

PUBMEDID 22205608

DOI 10.1080/14786435.2010.519353

WEB OF SCIENCE ID 000284540500008

DOI 10.1063/1.3658059

WEB OF SCIENCE ID 000301945200008

DOI 10.1002/NME.2936

WEB OF SCIENCE ID 000284204400003

WEB OF SCIENCE ID 000290705300199

Abstract

DOI 10.1007/S10439-009-9678-1

WEB OF SCIENCE ID 000265787100015

PUBMEDID 19319682

WEB OF SCIENCE ID 000263364700389

DOI 10.1016/J.ENGANABOUND.2007.12.003

WEB OF SCIENCE ID 000262890600007

Abstract

DOI 10.1121/1.2912438

WEB OF SCIENCE ID 000257768000034

PUBMEDID 18646982

DOI 10.1063/1.2906487

WEB OF SCIENCE ID 000254669900117

Abstract

DOI 10.1063/1.2885679

WEB OF SCIENCE ID 000254194400034

PUBMEDID 18315309

DOI 10.1002/NME.2102

WEB OF SCIENCE ID 000253694000007

Abstract

DOI 10.1088/0957-4484/19/03/035710

WEB OF SCIENCE ID 000252967700035

PUBMEDID 21817595

Abstract

DOI 10.1016/J.JBIOMECH.2007.11.011

WEB OF SCIENCE ID 000254677400008

PUBMEDID 18093598

WEB OF SCIENCE ID 000252056300027

DOI 10.1016/J.MEMSCI.2007.02.018

WEB OF SCIENCE ID 000245971600020

Abstract

DOI 10.1007/S10439-005-5788-6

WEB OF SCIENCE ID 000232758300012

PUBMEDID 16240090

Abstract

DOI 10.1016/J.JBIOMECH.2004.04.009

WEB OF SCIENCE ID 000227590400002

PUBMEDID 15713285

DOI 10.1016/J.FINEL.2004.10.009

WEB OF SCIENCE ID 000228126000006

WEB OF SCIENCE ID 000226378500717

Abstract

DOI 10.1016/J.JCRS.2004.10.048

WEB OF SCIENCE ID 000227227000031

PUBMEDID 15721706

DOI 10.1088/0266-5611/20/1/012

WEB OF SCIENCE ID 000220062200012

DOI 10.1016/S0045-7825(03)00429-8

WEB OF SCIENCE ID 000185690100005

Abstract

DOI 10.1121/1.1514932

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Abstract

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