MAE-IC 2024

MAE-Industry Connect 2024

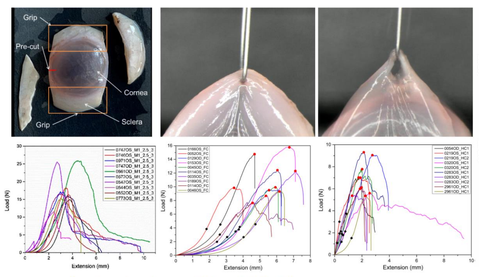
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

MECHANICS OF BIOLOGICAL SYSTEMS GROUP

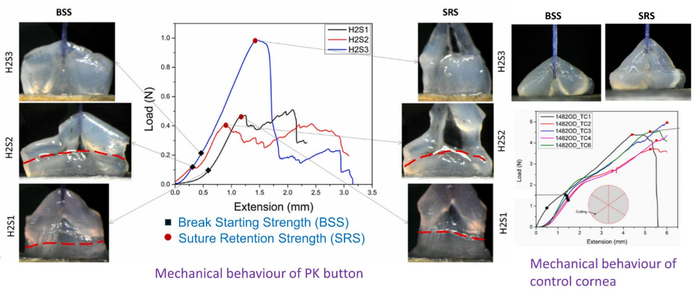
Fracture toughness, suture strength, and structure of corneal graft-host junction

S N S H Chittajallu[1,2,3], H Gururani[1], R Dalai[1], V K Saggam[1], S N Rath[1], S Jakati[2], S Basu[2], P K Vaddavalli[2], K M Tse[3], ***Viswanath C[1]***

[1] Indian Institute Technology Hyderabad, India; [2] LV Prasad Eye Institution, Hyderabad, India; [3] Swinburne University of Technology, Melbourne, Australia



Fracture toughness, BSS, and SRS of human cornea



Mechanical behaviour of PK button

Mechanical behaviour of control cornea

1. Fracture behavior in corneal specimens depends on notch size and location, with lamellar tear and collagen fiber pull-out as failure mechanisms.
2. A rare corneal graft that failed after 13 years of PK is investigated. The Graft-Host-Junction(GHJ) strength observed is 1/10th of the control Cornea, and the microstructural characteristics showed remodeling at the wound junction.

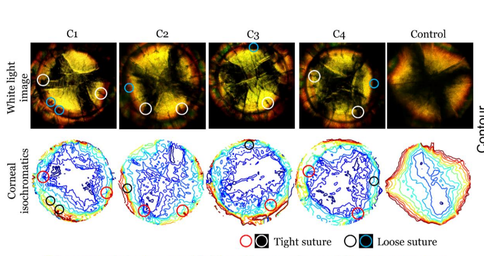
Publications:

1. *Investigation of microstructural failure in the human cornea through fracture tests. Scientific Report 2023; 13:13876*
2. *Investigation of mechanical strength and structure of corneal graft-host junction. Heliyon 2024; 10; e30871*
3. *A study on suture retention strength in human cadaver corneas was conducted, and it is submitted to the Scientific Reports (Under review)*

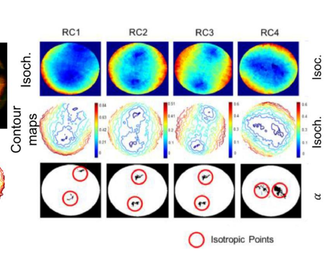
Subject-Specific Corneal Microstructure and Post-PK Misalignment Through Birefringence

H Gururani[1], S N S H Chittajallu[1,2], M Doulatramani[1], ***M Ramji[1]****, Sayan Basu[2],* ***Viswanath C[1]***

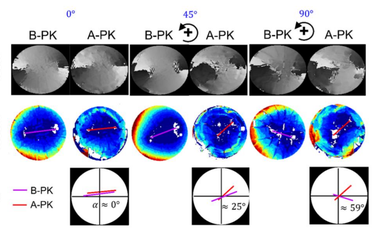
[1] Indian Institute Technology Hyderabad, India; [2] LV Prasad Eye Institution, Hyderabad, India



Fringe morphology around tight and loose sutures of the human cornea



Isotropic points of the rabbit corneas



Host-Donor misalignment

1. Individual suture tension and interactions significantly influence tissue configuration during corneal transplantation, affecting visual outcomes.
2. Rabbit corneas exhibited inter-corneal variability in birefringence with different degrees of biaxiality, similar to human corneas.
3. The structural misalignment and suture tension collectively influence the suture-tissue interaction, resulting in an erratic change in the corneal birefringence after PK.

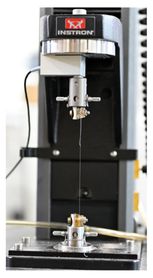
Publications:

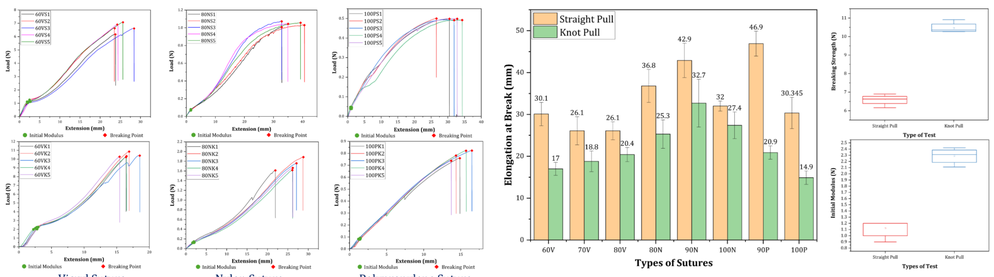
1. *An In-Vitro Investigation on the Birefringence of the Human Cornea Using Digital Photoelasticity. Experimental Mechanics 2023; 63:205–19.*
2. *Identification of subject-specific fibrillar disposition in healthy rabbit cornea through birefringence analysis. Optics and Lasers in Engineering 2023; 169; 107747*
3. *Intraoperative collagen imaging of sutured cornea: A way towards managing post-penetrating keratoplasty astigmatism. Medical Engineering and Physics 2024; 123; 104076.*

Tensile Properties of Ophthalmic Sutures

R Dalai[1], V K Saggam[1], S N S H Chittajallu[1,2], ***M Ramji[1]****, S Basu[2],* ***Viswanath C[1]***

[1] Indian Institute Technology Hyderabad India; [2] LV Prasad Eye Institution, Hyderabad, India;





Mechanical behaviour of ophthalmic sutures in Straight pull and knot pull test

1. The mechanical properties of ophthalmic suture materials (Vicryl, polypropylene, Nylon) are investigated. The mechanical properties play a critical role in withstanding different intraocular pressures.
2. Load-displacement curves determine vital parameters such as initial modulus, breaking strength, and elongation at break.
3. The suture mechanical properties provide valuable insights to surgeons in optimizing suture material selection for ophthalmic surgeries.

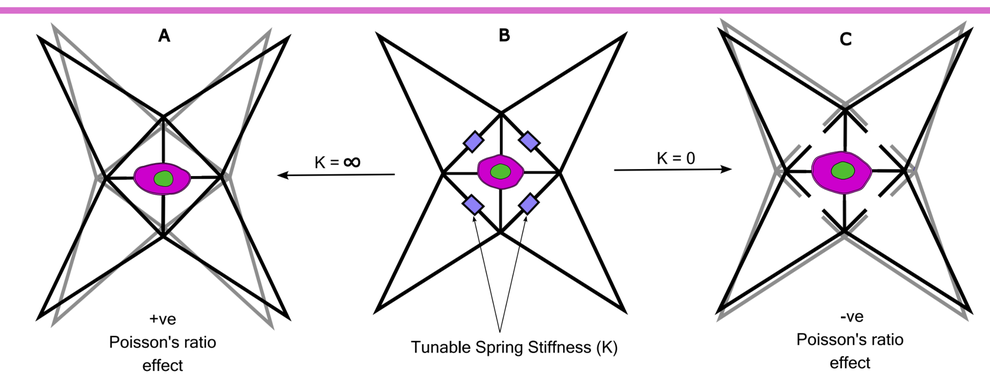
Dr. Viswanath Chinthapenta
viswanath@mae.iith.ac.in

Areas of Research :
- ❖ Nano and Micro-mechanics
- ❖ Fracture Mechanics
- ❖ Contact mechanics
- ❖ Bio-Mechanics
- ❖ Structural Health Monitoring

Dr. Ramji Manoharan
ramji_mano@mae.iith.ac.in

Areas of Research :
- ❖ Experimental Solid Mechanics,
- ❖ Material Characterisation,
- ❖ Finite Element Analysis,
- ❖ Fracture Mechanics,
- ❖ Composite Structures,
- ❖ Damage Mechanics

Google Scholar Link



The mechanical properties of substrates, such as Elastic Modulus and Poisson's ratio, strongly influence the behavior of adhered biological cells. While tunable materials like polyacrylamide gels and hydrogels have been used to study this, they do not allow for in situ changes to their elastic properties during cell growth. This research proposes an alternative using tunable compliant micro-mechanism substrates, allowing real-time adjustment. The mechanism exhibits an invertible Poisson's ratio, switching between positive and negative values. By altering the stiffness of a re-entrant structure, lateral deformation direction reverses, with analytical models and experiments confirming this behavior.

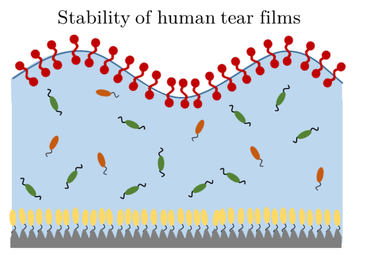
Publication:

Sebastian, M., Balakrishnan, S. and ***Palathingal, S****., 2023, August. Design and Modelling of Compliant Mechanisms With Invertible Poisson's Ratio Effect for Growing Biological Cells. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (Vol. 87363, p. V008T08A027). American Society of Mechanical Engineers.*

Dr. Safvan Palathingal
safvan@mae.iith.ac.in

Areas of Research :
- ❖ Nonlinear mechanics of slender structures
- ❖ Compliant mechanisms
- ❖ Optimization

Google Scholar Link



Publication:

Mohar Dey, Atul Vivek, Harish N. Dixit, A. Richhariya, James J. Feng. Journal of Fluid Mechanics. 858:352-76, 2019
Anjishnu Choudhury, Mohar Dey, Harish N. Dixit, and James J. Feng, Phys. Rev. E 103, 013108, 2021

Dr. Harish Nagaraj Dixit
hdixit@mae.iith.ac.in

Areas of Research :
- ❖ Interfacial fluid mechanics,
- ❖ Vortex dynamics,
- ❖ Hydrodynamic stability theory,
- ❖ Geophysical flows.

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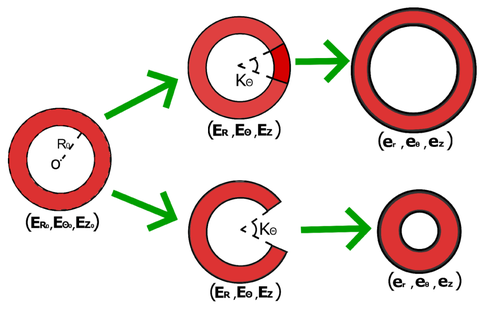


At the SUCSHM (Searching Unique Class of Small-scale High-performance Materials) Lab, we explore a wide range of biophysical phenomena—from fundamental questions like why plants exhibit specific growth patterns to advanced modeling of residual stresses in biological tissues, particularly cancerous tissue. Our focus lies in the modeling and simulation of complex biophysical problems. By deriving new theories and validating them against the natural laws of physics, we aim to understand the mechanisms driving these processes.

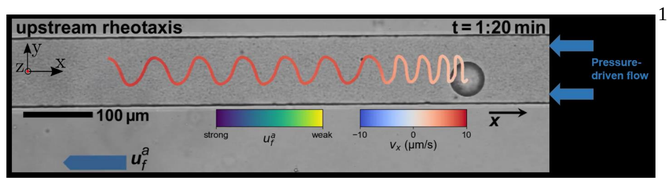
Dr. Prakhar Gupta
prakharg@mae.iith.ac.in

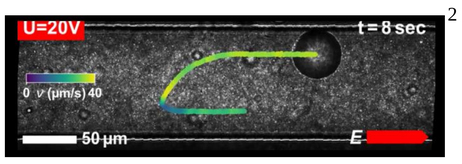
Areas of Research :
- ❖ Multiscale and multiphysics modeling
- ❖ Computational materials science
- ❖ Nonlinear elasticity
- ❖ Biomechanics
- ❖ Computational mechanics

Google Scholar Link

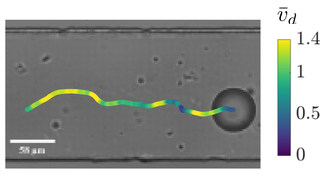
Dynamics of Self-propelled Microswimmers in Complex Environment

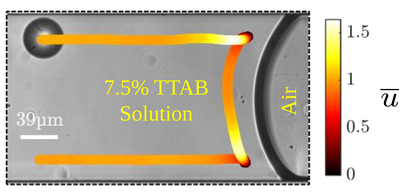
Smita S. Sontakke, Subhasish Guchhait, Aneesha Kajampady, ***Ranabir Dey***





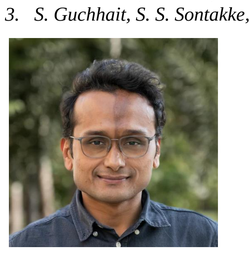
Electrotaxis of artificial microswimmers





Publications:

1. ***R. Dey****, C. M. Buness, B. V. Hokmabad, C. Jin, C. C. Maass,* ***Nature Communications 13, 2952, 2022****.*
2. *C. M. Buness, A. Rana, C. C. Maass,* ***R. Dey****, arXiv:2401.14376v1, 2024.*
3. *S. Guchhait, S. S. Sontakke, S. Mandal,* ***R. Dey****, arXiv:2407.04324v1, 2024, under review*



Dr. Ranabir Dey
ranabir@mae.iith.ac.in

Areas of Research :
- ❖ Low Reynolds number fluid mechanics
- ❖ Microfluidics
- ❖ Capillarity and wetting phenomena
- ❖ Active soft matter- dynamics of self-propelling microswimmers (e.g. swimming droplets) in complex surroundings

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