

Breaking Corneal Barriers: GelMA-Based Hybrid Microneedles for Enhanced Intrastromal Drug Delivery

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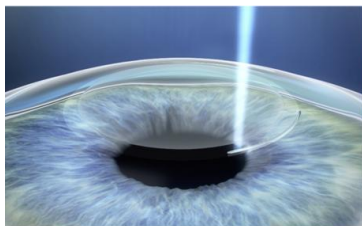
³Department of Mechanical and Industrial Engineering, University of Illinois Chicago, Chicago, IL, USA.

Through My Eyes: Rethinking Trans-corneal Drug Delivery

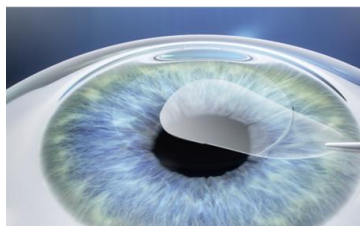


Even the safest **ocular procedures** can feel **terrifying** in the moment.

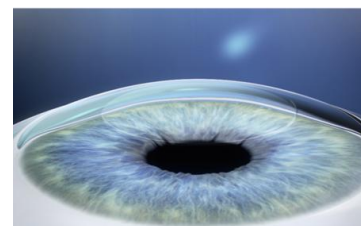
Next-Gen Refractive Surgery (SMILE®: Small Incision Lenticule Extraction)



Step 1: Laser cuts lenticule



Step 2: Surgeon removes lenticule



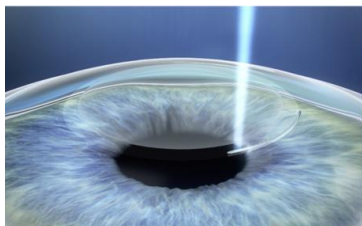
Step 3: Cornea reshaped

Through My Eyes: Rethinking Trans-corneal Drug Delivery

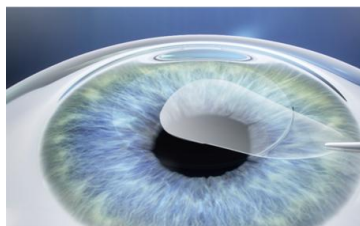


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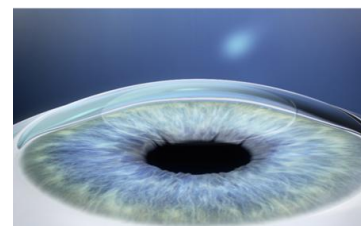
Next-Gen Refractive Surgery (SMILE®: Small Incision Lenticule Extraction)



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Step 3: Cornea reshaped

But for many patients, **invasive approaches** are still the standard of care...

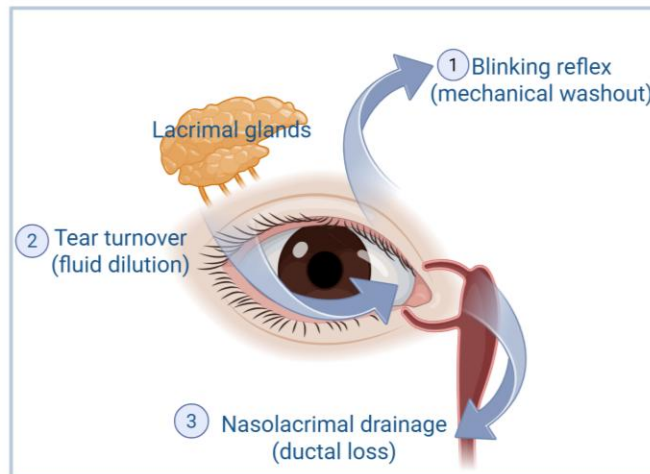
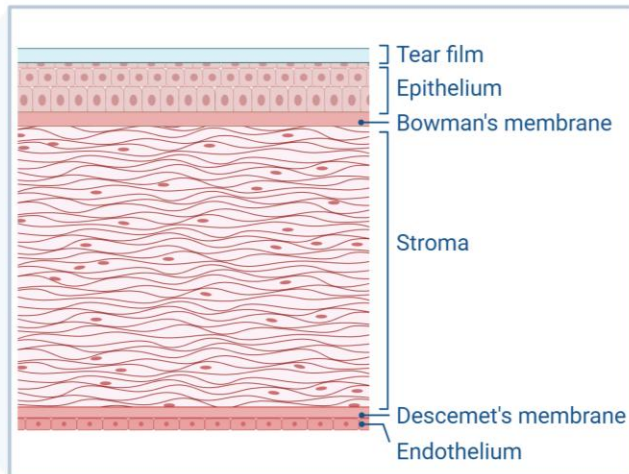
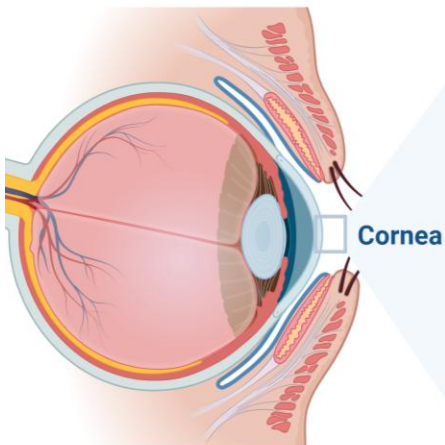
Source: [Intrastromal Antifungal Injection, Sharjeel Eye, YouTube \(2024\)](#).



Why Are We Still Struggling With Trans-corneal Drug Delivery?

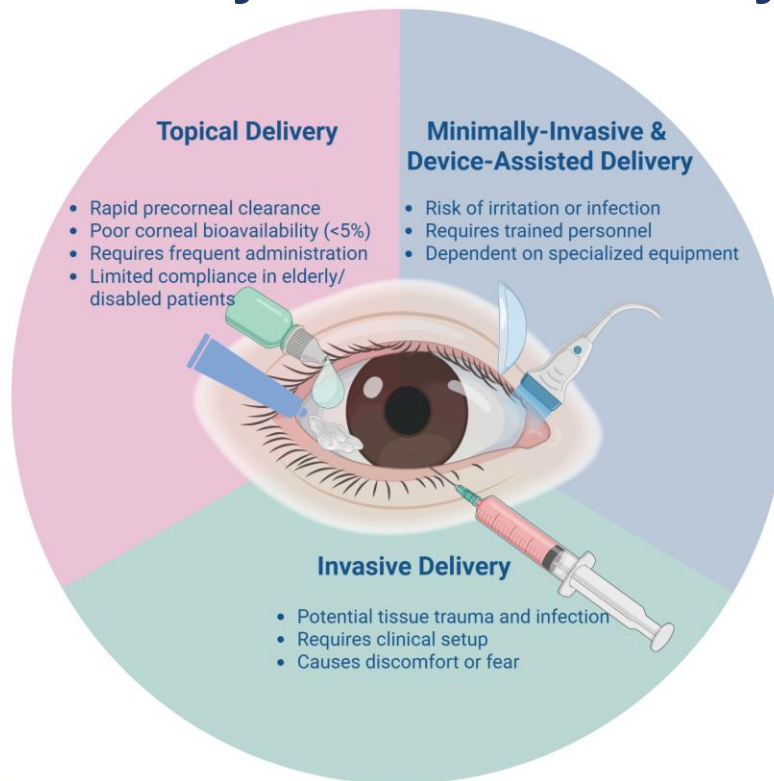
Static Barriers

Dynamic Clearance Pathways



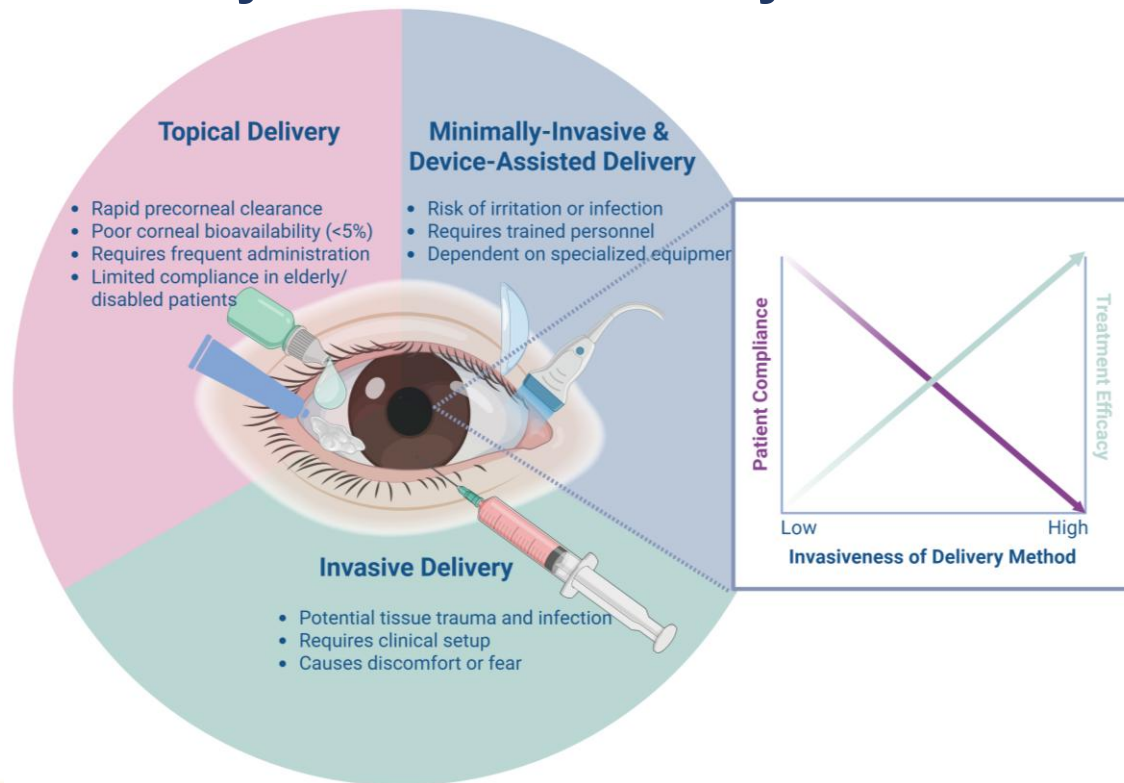
Li et al., *Adv Drug Deliv Rev.* 2023;198:114868.

The Trans-corneal Delivery Dilemma: Efficacy vs. Accessibility



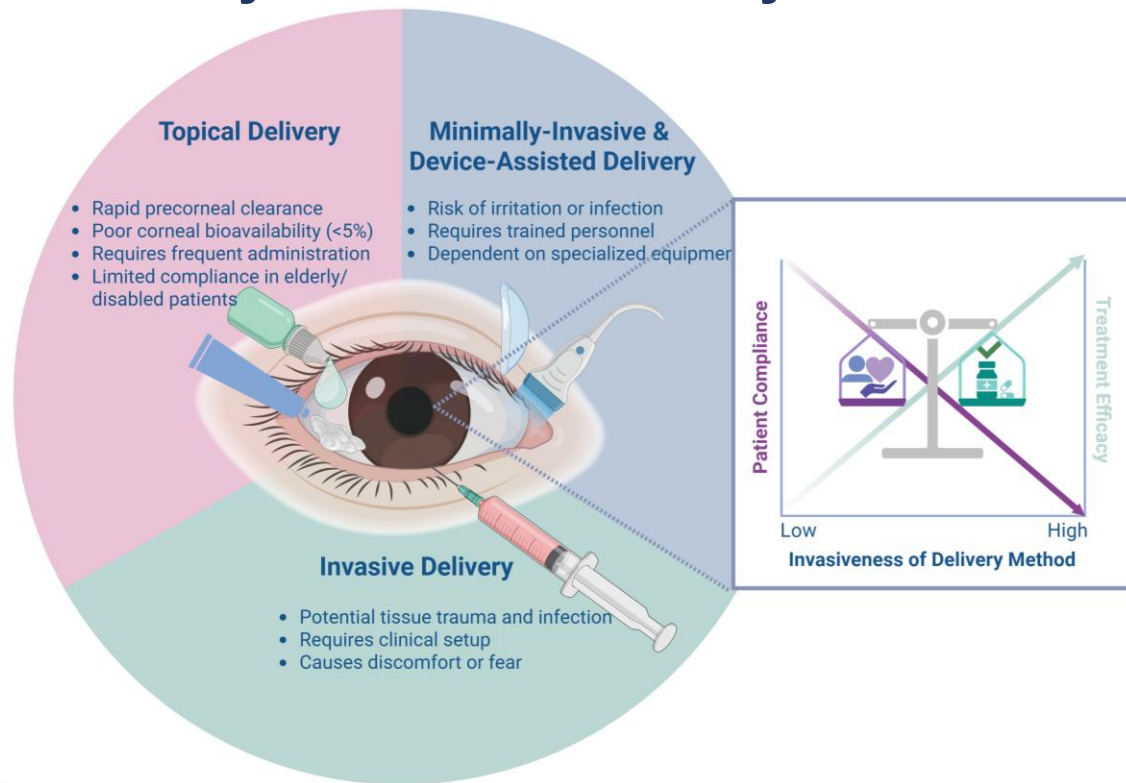
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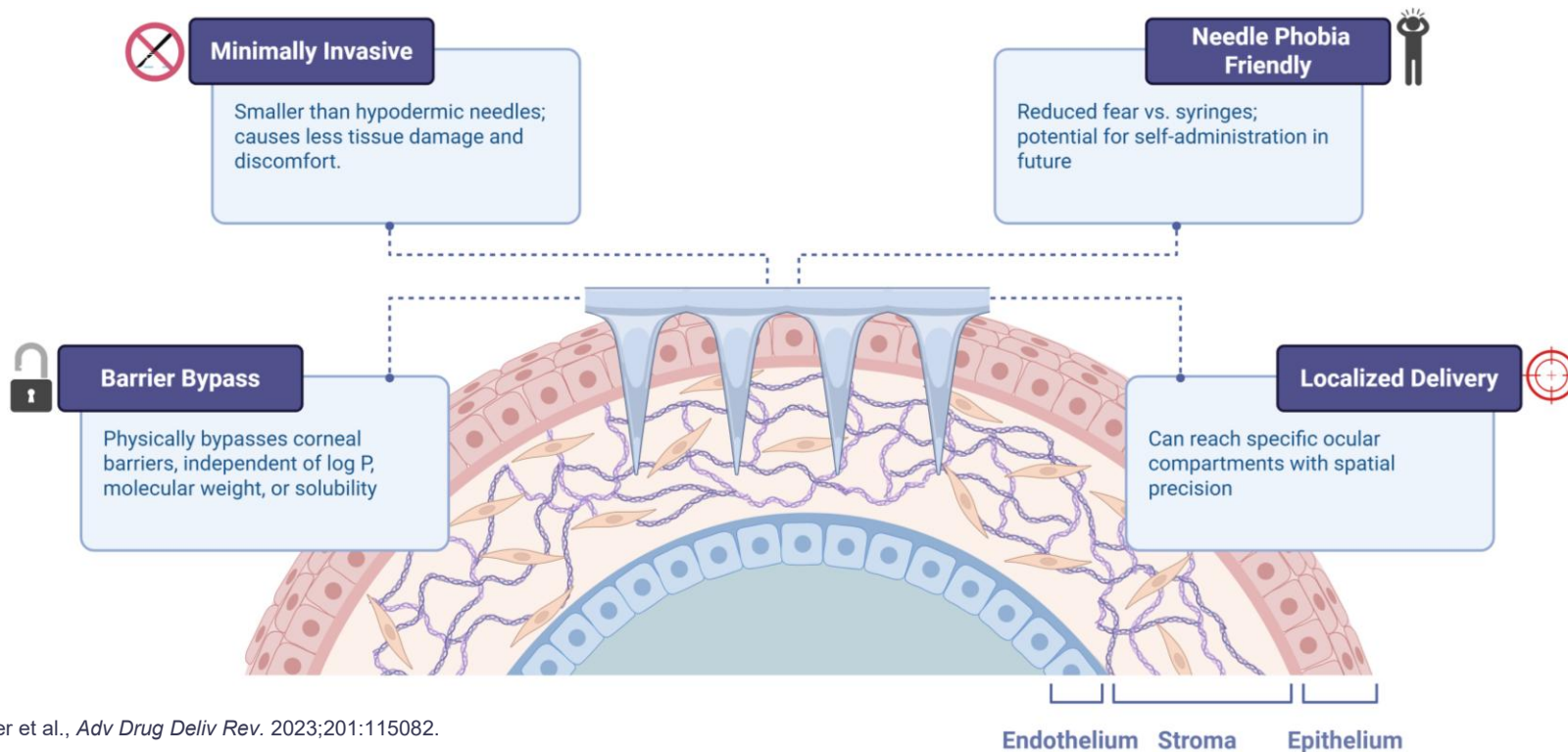
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The Trans-corneal Delivery Dilemma: Efficacy vs. Accessibility



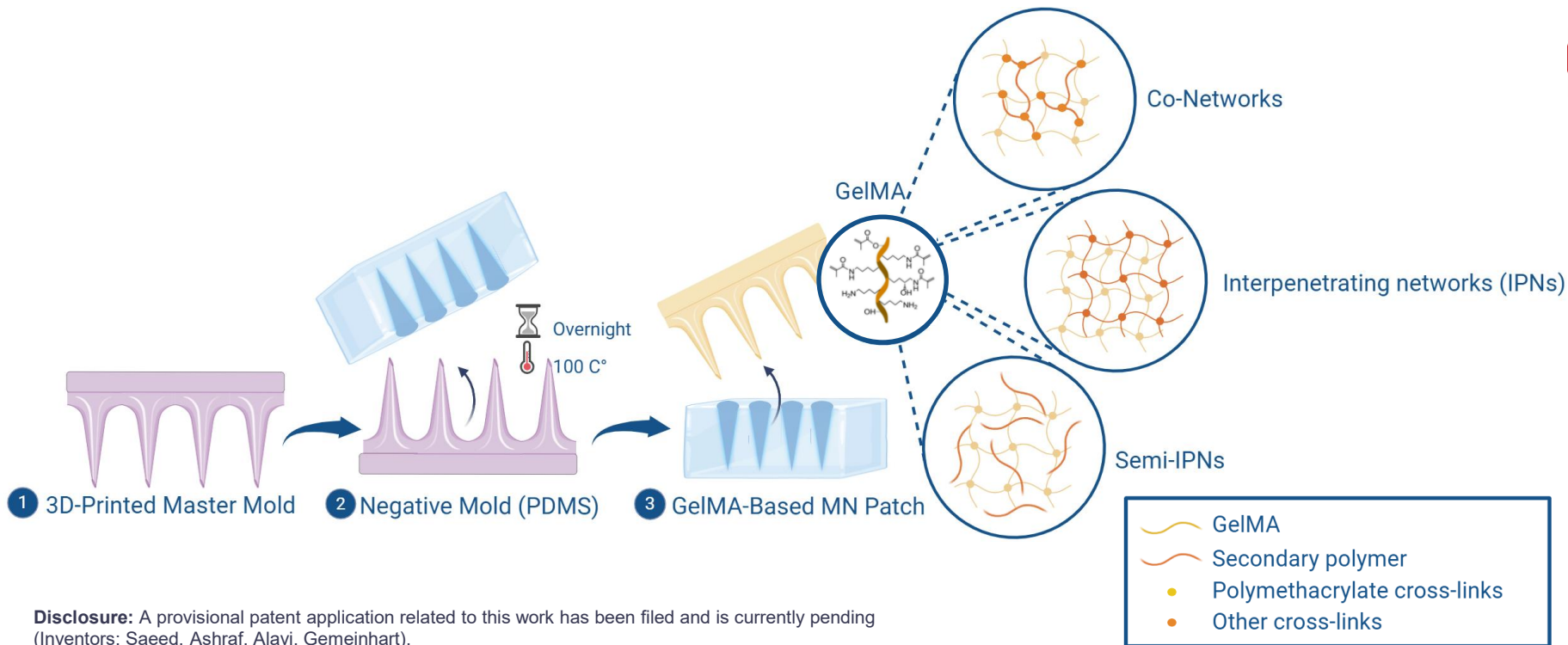
Li et al., *Adv Drug Deliv Rev.* 2023;198:114868.

Microneedles (MNs): Breaking the Barrier, Minimally

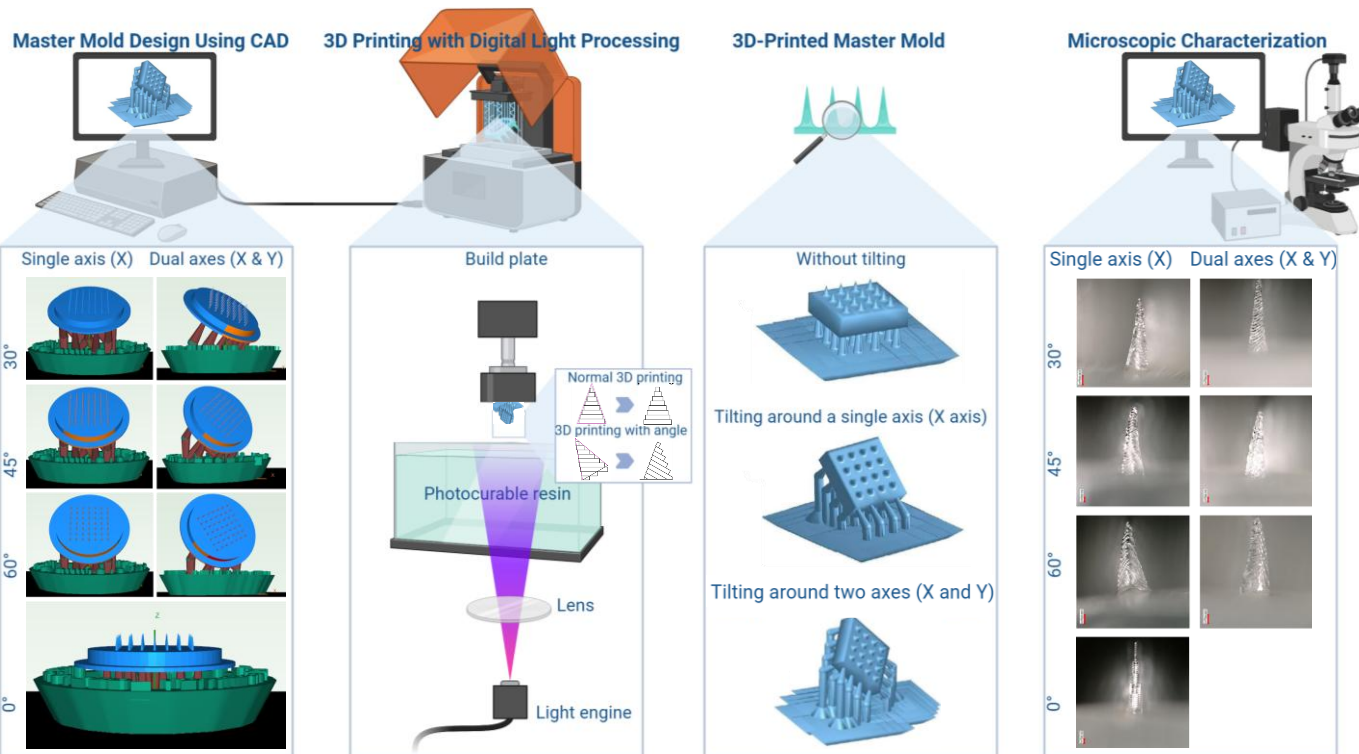


Glover et al., *Adv Drug Deliv Rev.* 2023;201:115082.

Our Approach: A GelMA-Based MN Patch Tailored for the Cornea



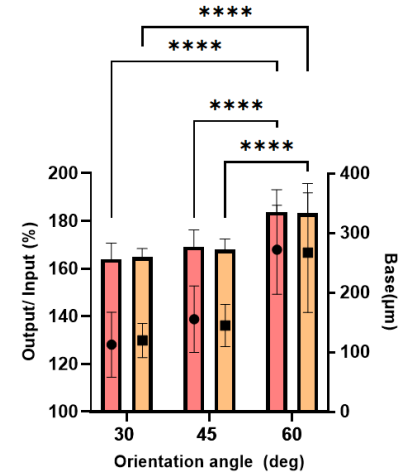
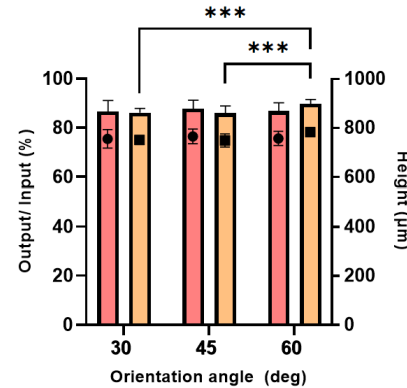
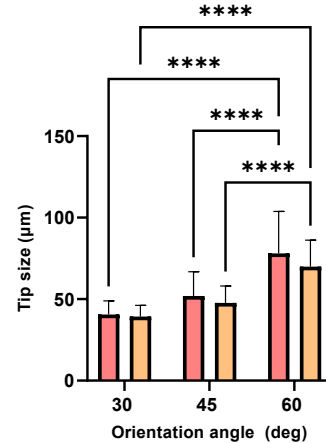
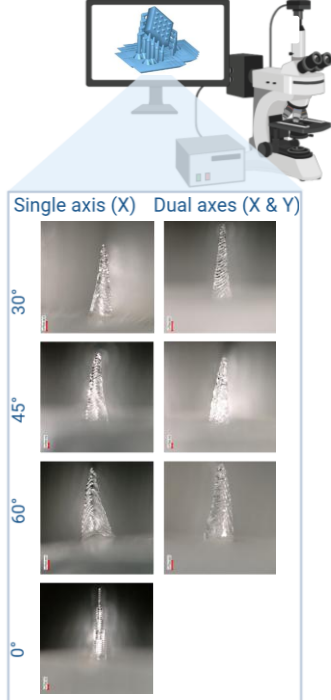
Engineering MNs: From CAD Design to Functional Patch



Optimizing Tilt for Sharper Molds: 30° Wins, Axis Doesn't Matter



Microscopic Characterization

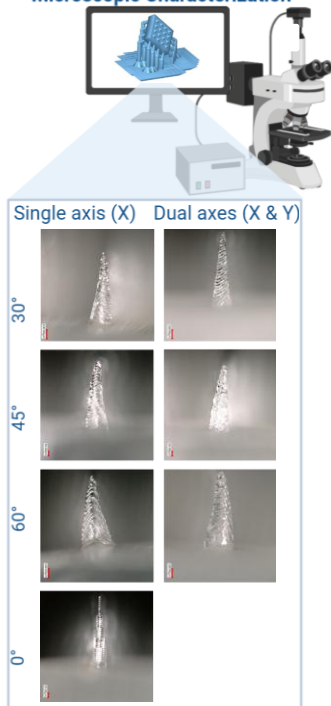


CAD Design: Height: 1150 μm, Base: 200 μm

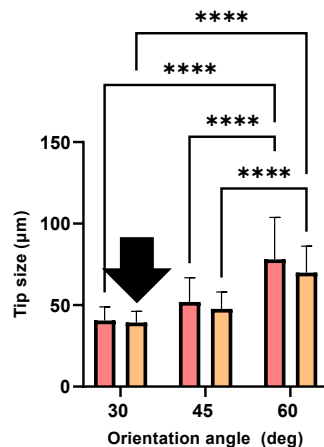
- Single axis (X)
- Dual axes (X & Y)
- Output/ Input (%) for single axis (X)
- Output/ Input (%) for dual axes (X & Y)

Optimizing Tilt for Sharper Molds: 30° Wins, Axis Doesn't Matter

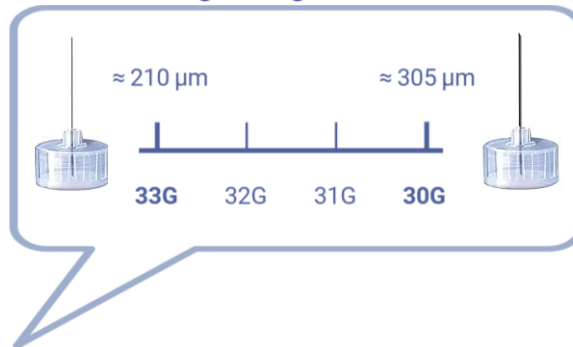
Microscopic Characterization



Clinical Needle Gauge Range for Intrastromal Injection

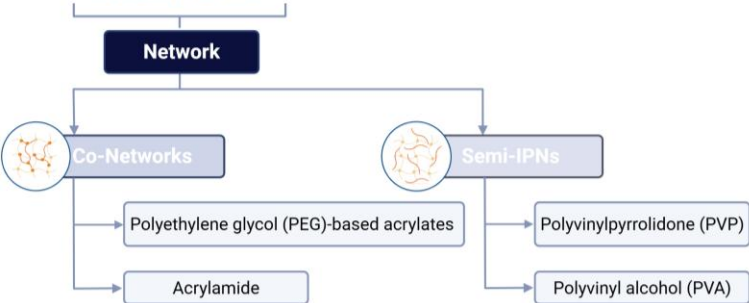
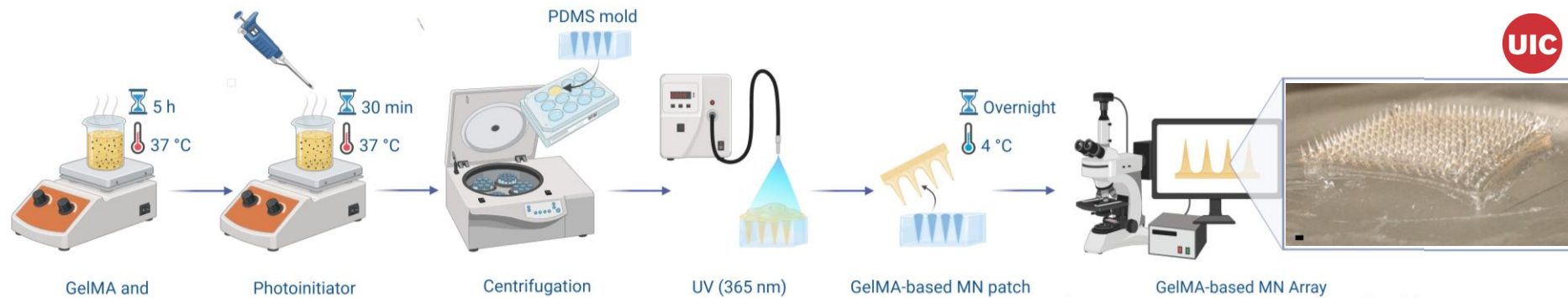


CAD Design: Height: 1150 μm, Base: 200 μm



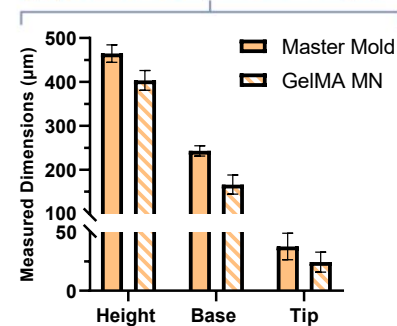
- Single axis (X)
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From Mold to Patch: A Workflow for High-Fidelity Replication

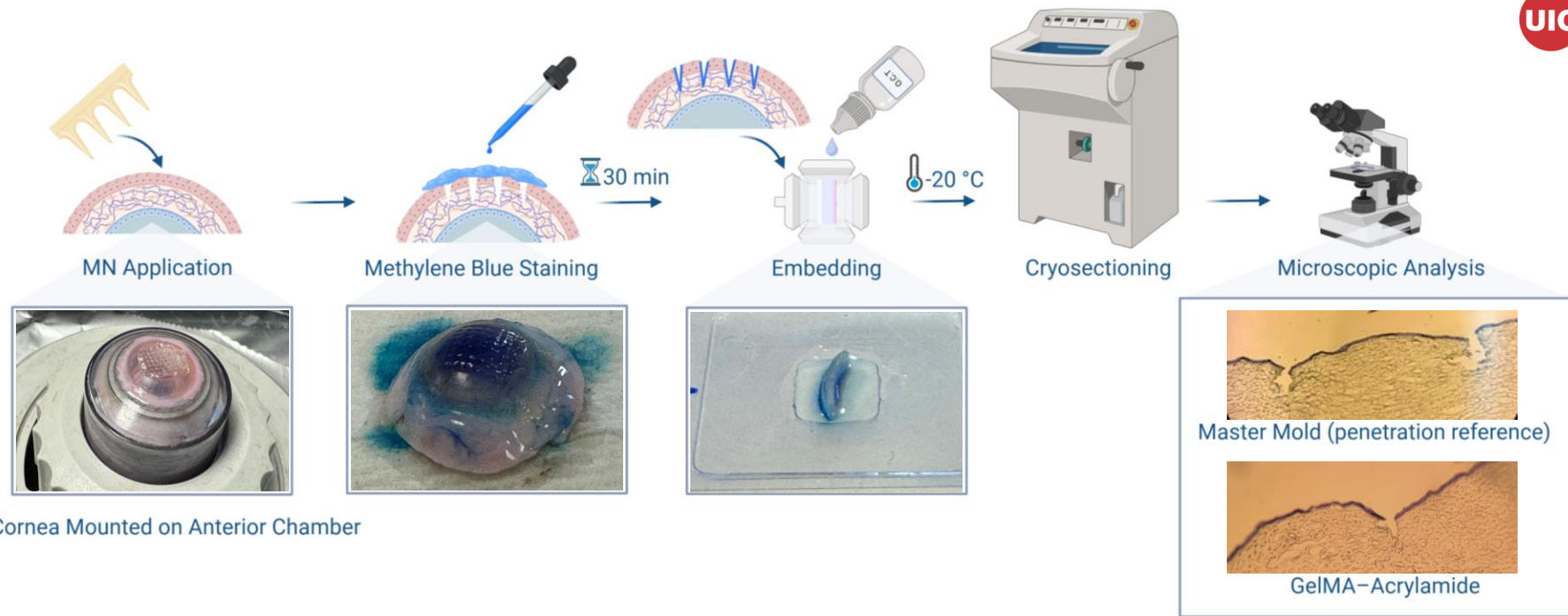


*Formulation development is ongoing.

GelMA-based MN Array
(Representative formulation: GelMA-Acrylamide)
(Keyence VHX-6000 | Scale bar: 200 μm)

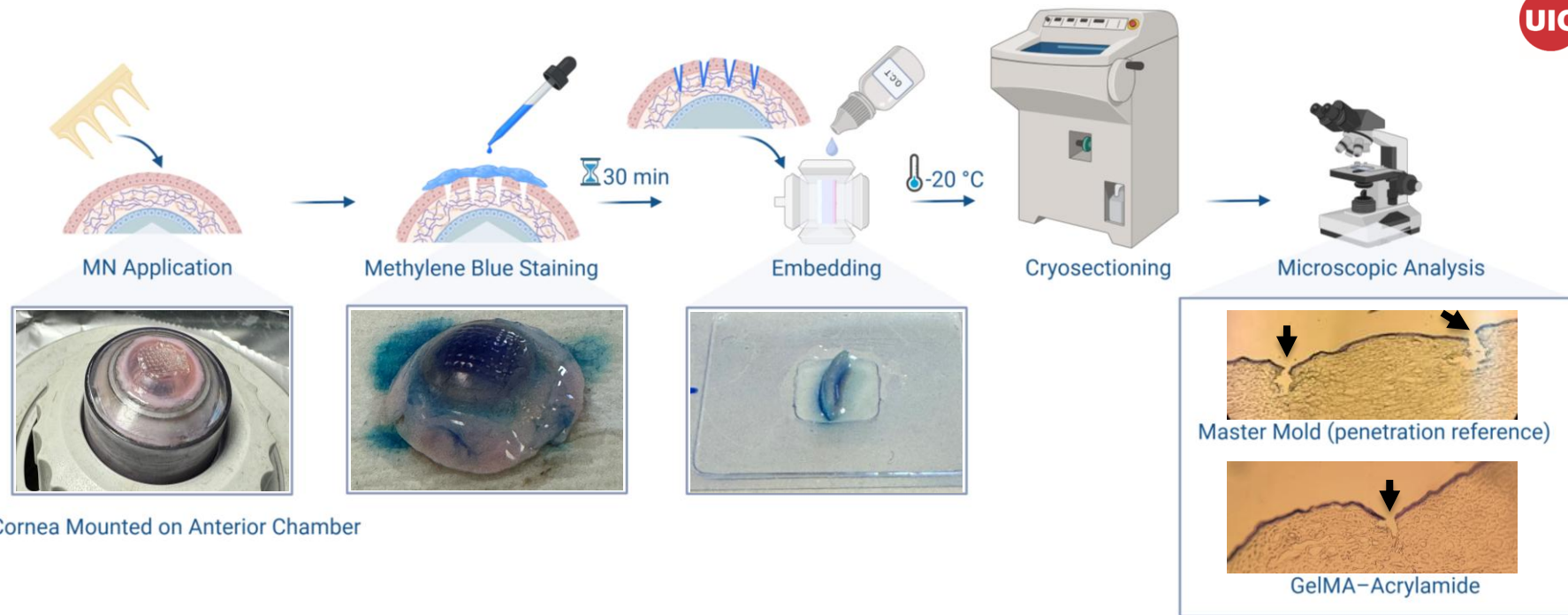


Toward Translation: Human Corneal Evidence of MN Penetration



Human Cornea Mounted on Anterior Chamber

Toward Translation: Human Corneal Evidence of MN Penetration



Human Cornea Mounted on Anterior Chamber

The Team Behind the Vision

Primary Advisor

Prof. Richard A. Gemeinhart

Gemeinhart Lab

Angeliki Andrianopoulou

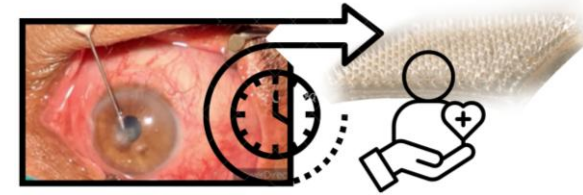
Jay Teamer

Elisabeth Gutierrez Manzanares

Collaborators

Prof. Hajirah N. Saeed

Prof. Jie Xu



*Yesterday's care caused fear.
Tomorrow's? Precision with comfort.
No compromise!*



Figures were created with **BioRender.com**