

**A NOVEL BIOMECHANICAL  
SIMULATION AND ARTIFICIAL  
INTELLIGENCE SOFTWARE FOR  
PREDICTION OF POST-REFRACTIVE  
SURGERY CORNEAL STIFFNES**

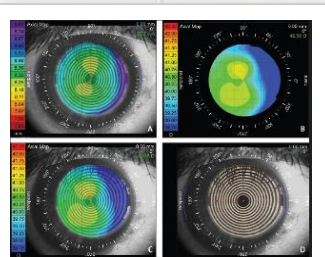
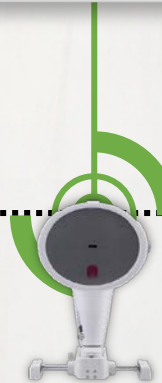
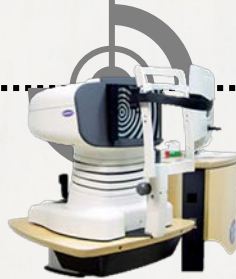
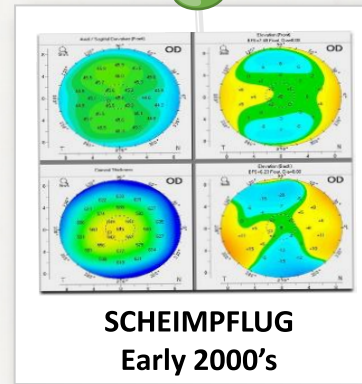
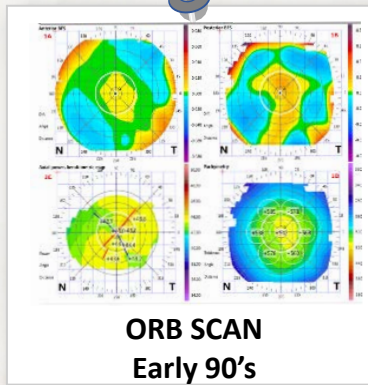
**PRESENTING AUTHOR:** DR POOJA  
**KHAMAR**  
**CO AUTHORS :** DR ROHIT SHETTY, DR ABHIJIT SINHA ROY,  
MATHEW FRANCIS,

CATARACT, REFRACTIVE OPTICS AND CLINICAL RESEARCH,  
NARAYANA NETHRALAYA, BENGALURU



**NO FINANCIAL DISCLOSURES**

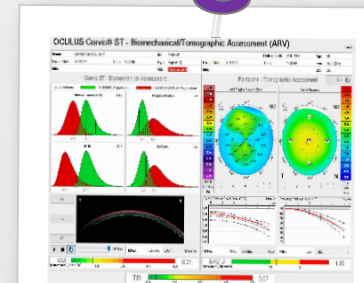
# EVOLUTION OF DIAGNOSTIC MODALITIES IN REFRACTIVE SURGERY FOR PERFECT DECISION MAKING

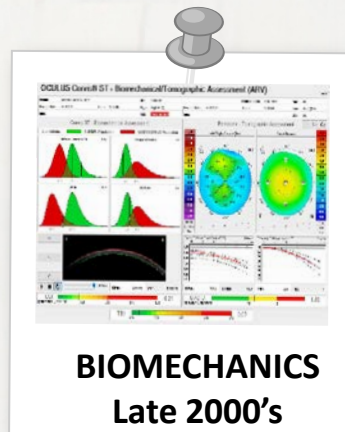
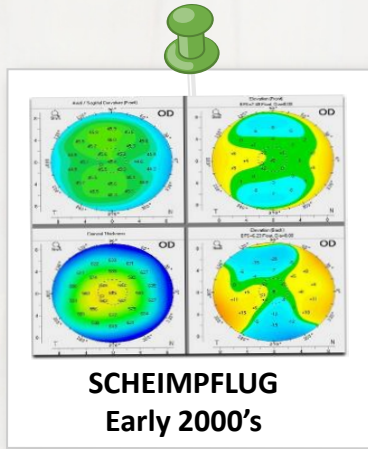


**ECTASIA RISK SCORE SYSTEM**

PARAMETER	POINTS			
	4	3	2	1 0
TOPOGRAPHY PATTERN	Abnormal	Inf. Steep/ SBA	ABT	Normal/SBT
RSB	<400 µm	240-250 µm	260-275 µm	280-299 µm >300 µm
AGE	<18 yrs	18-21 yrs	22-25 yrs	26-29 yrs >30 yrs
CORNREAL THICKNESS	<450 µm	451-480 µm	481-510 µm	>510 µm
MISE	>14 D	>12 to 14 D	>10 to 12 D	>8 to 10 D 8 D or less

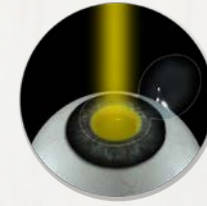
**RISK SCORING SYSTEMS**





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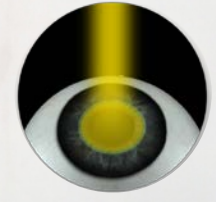
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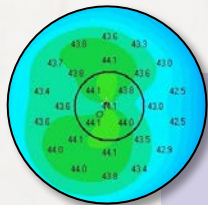
**LASIK**



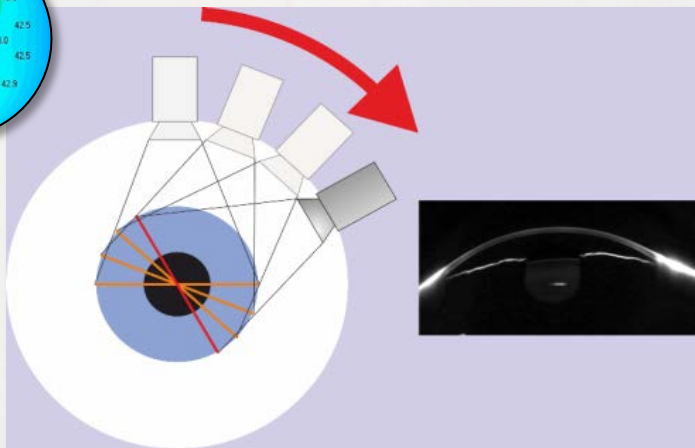
**SMILE**



**TRANS PRK**

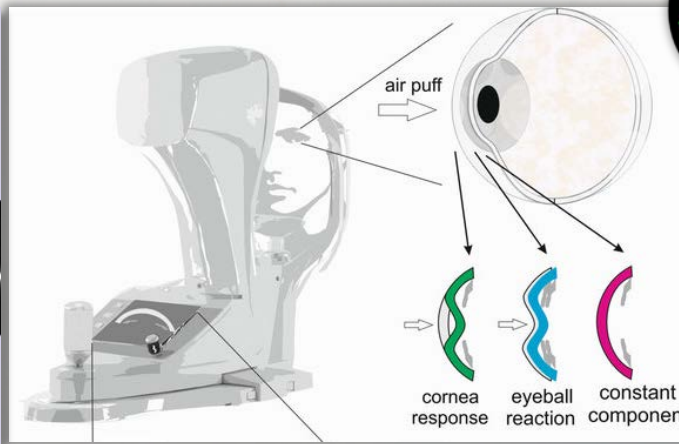


**CORNEAL TOPOGRAPHY**



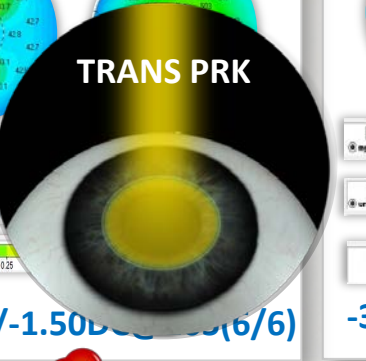
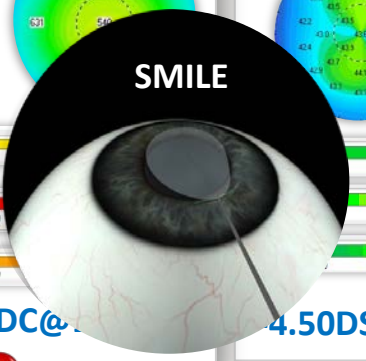
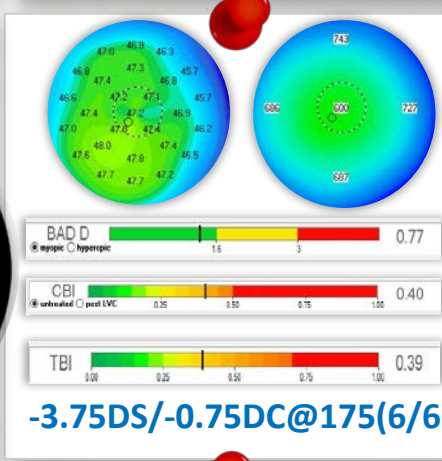
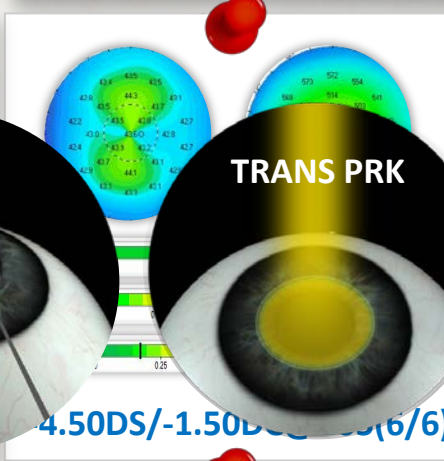
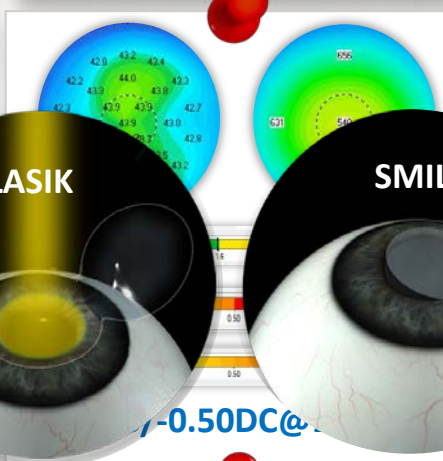
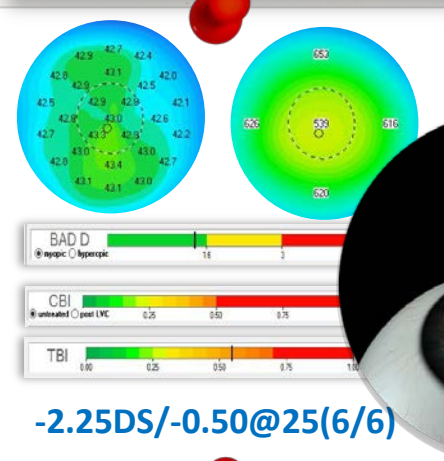
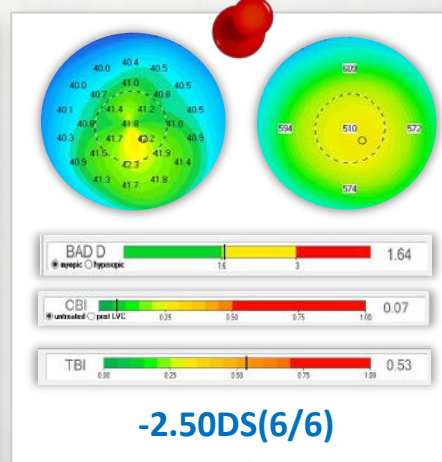
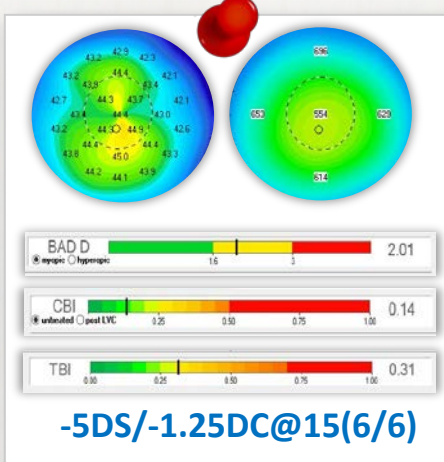
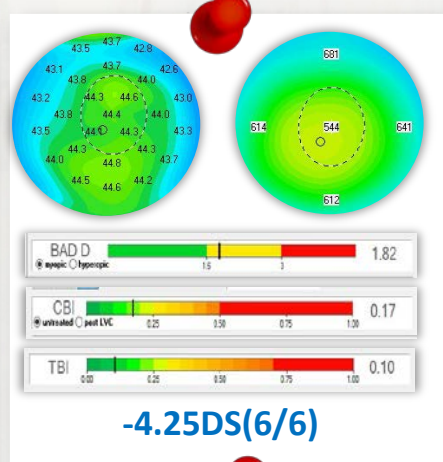
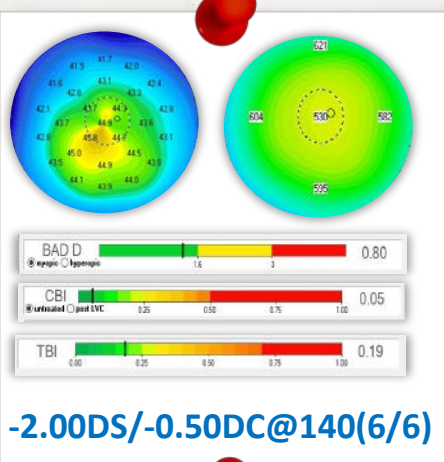
**CORNEAL STRUCTURE**

**CORNEAL BIOMECHANICS**

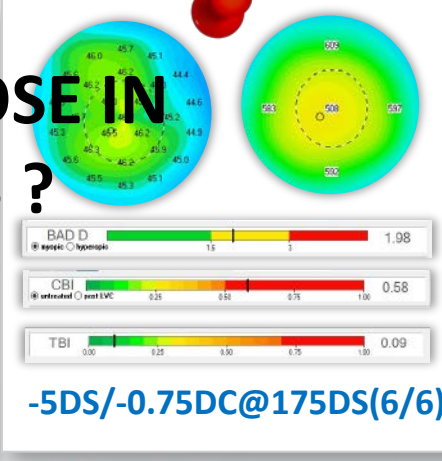
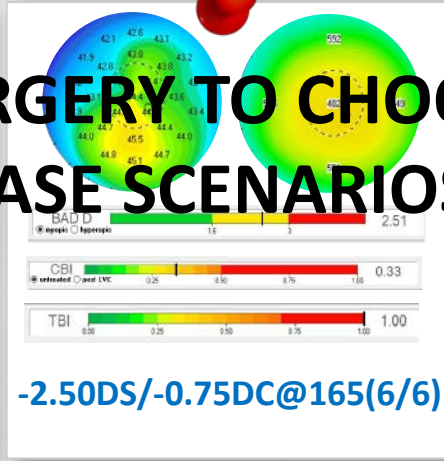
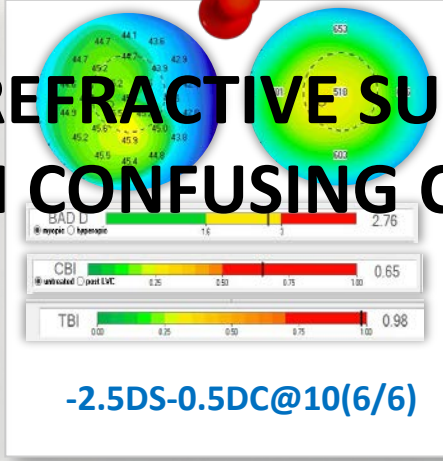
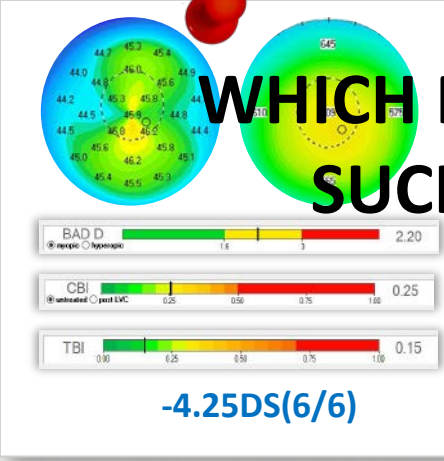


**CORNEAL STRENGTH**





**WHICH REFRACTIVE SURGERY TO CHOOSE IN SUCH CONFUSING CASE SCENARIOS ?**





# RESEARCH QUESTIONS



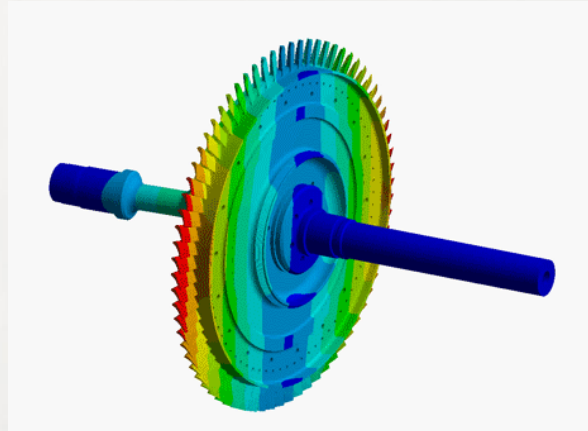
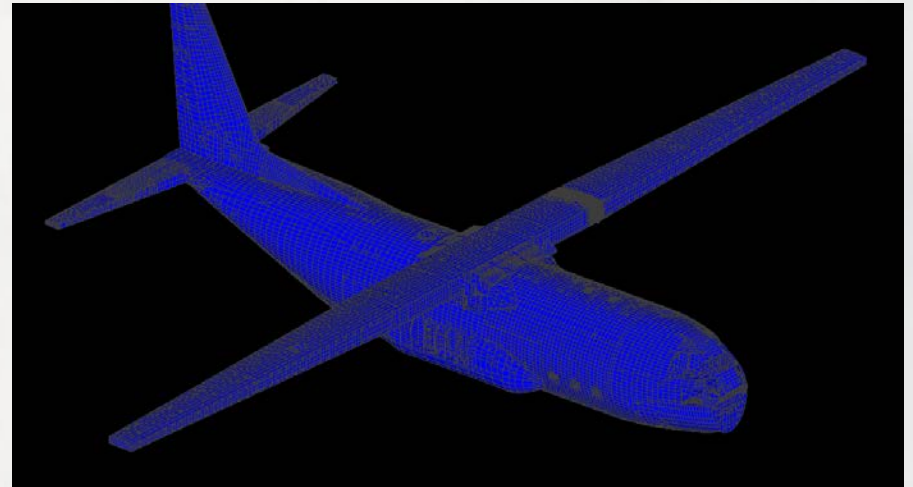
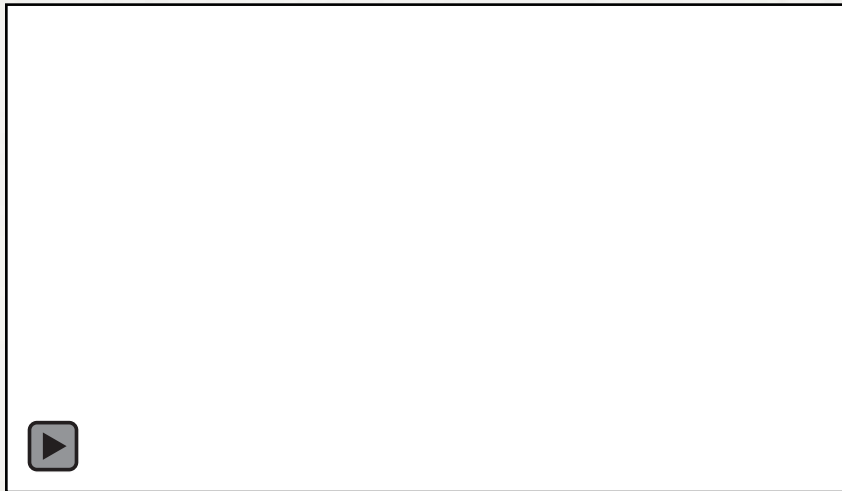
IS THERE A WAY WHERE WE CAN  
CHOOSE A RIGHT REFRACTIVE SURGERY PROCEDURE  
FOR SUCH CASE SCENARIOS ?

IS THERE A WAY WE CAN PREDICT THE OUTCOMES OF  
REFRACTIVE SURGERY ?  
(POST REFRACTIVE SURGERY CORNEAL STRENGTH)



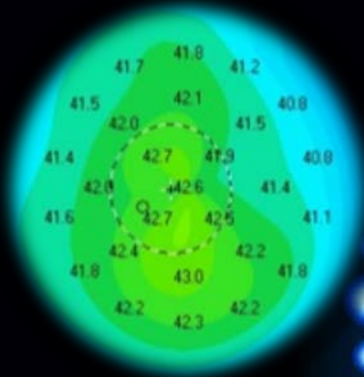
# WHAT IS FINITE ELEMENT METHOD (FEM) ?

FEM is a numerical technique that subdivides a large complex system into smaller, simpler, parts, called **finite elements**.

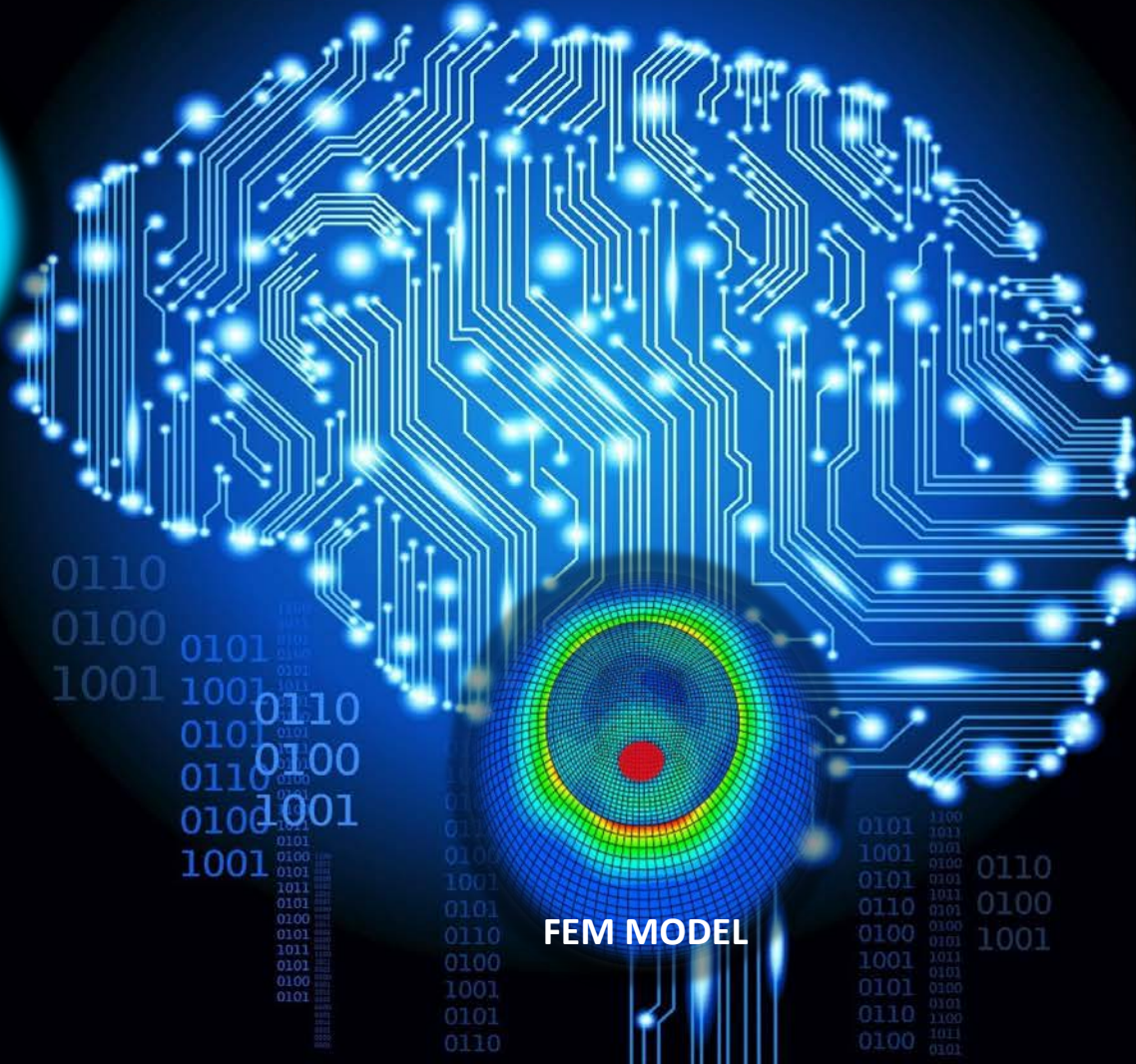


Wide applications in aeronautical, automotive and biochemical industries

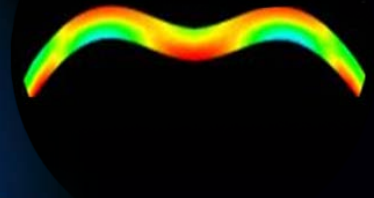
# TRANSLATING RESEARCH INTO PRACTICE



**TOPOGRAPHY**



**FEM MODEL**



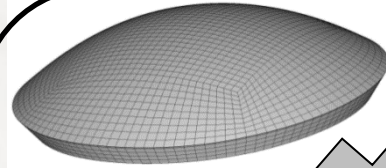
**BIOMECHANICS**

**ARTIFICIAL INTELLIGENCE (AI) BASED SIMULATION PLATFORM FOR PLANNING REFRACTIVE SURGERY**

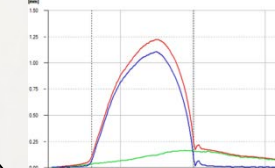
# HOW PREDICTION MODEL WAS CREATED TO PREDICT POST REFRACTIVE SURGERY OUTCOMES ?



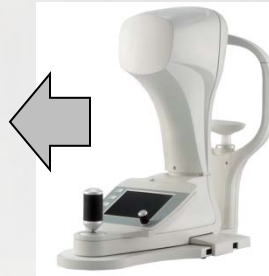
Pentacam HR



Corneal mesh



Deformation waveform

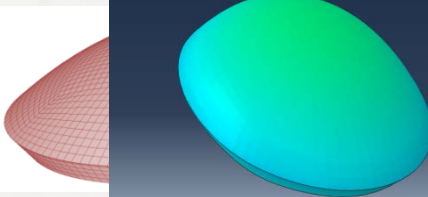


Corvis-ST

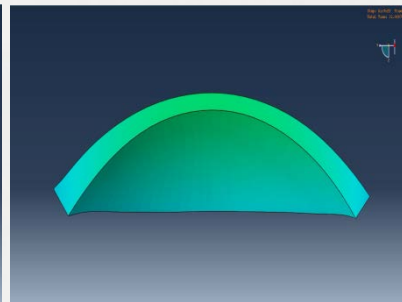
## Surgical Parameters

- Planned refraction
- Surgery type
- Flap/cap settings
- Optical zone

Inverse FEM

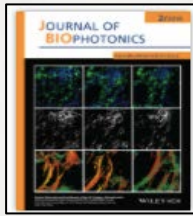


Cornea optimized ablation



AI adjustment

Postoperative corneal stiffness



# Corneal tomographic features of postrefractive surgery ectasia

Pooja Khamar, Ritika Dalal, Rachana Chandapura, Mathew Francis, Rohit Shetty, Everette J. R. Nelson, Rudy M. M. A. Nuijts, Abhijit Sinha Roy\*



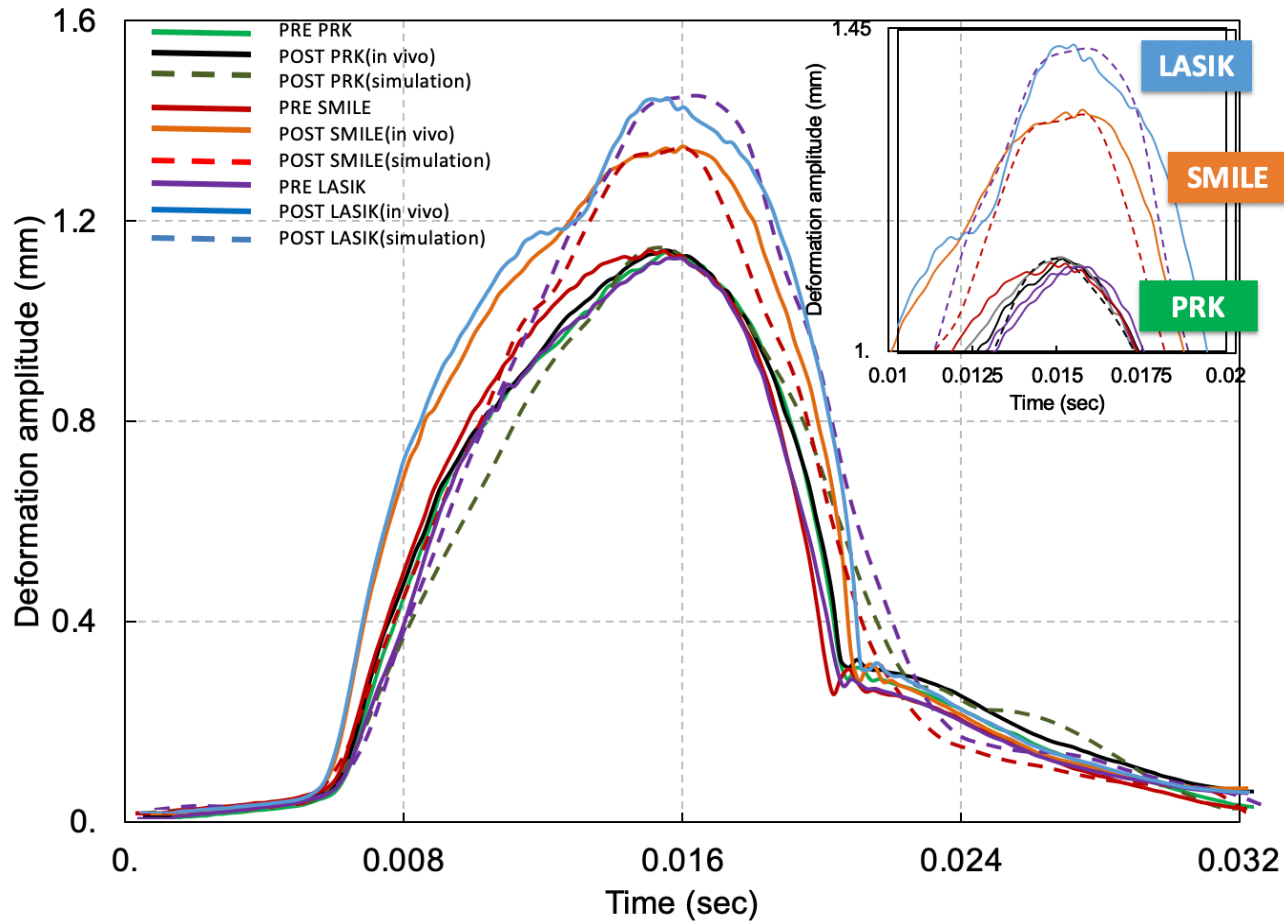
# REVIEW OF LITERATURE

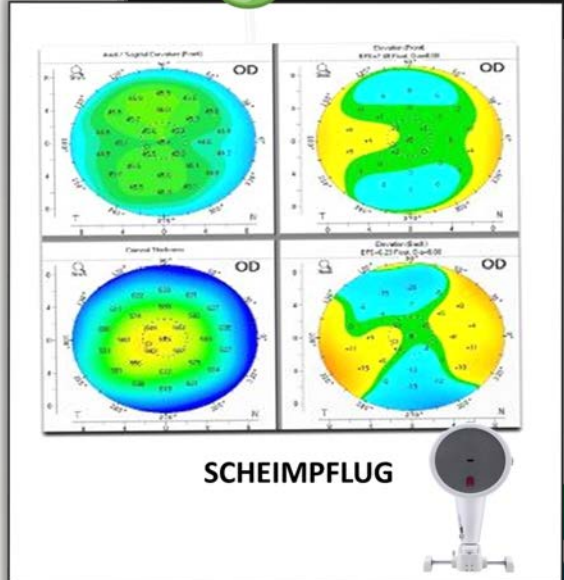


Cornea

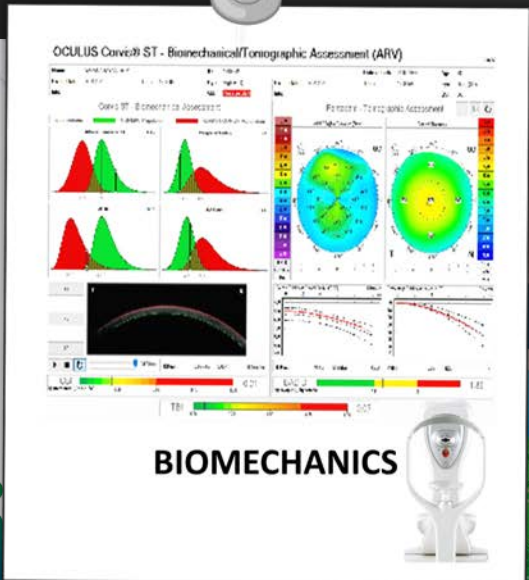
## In Vivo Prediction of Air-Puff Induced Corneal Deformation Using LASIK, SMILE, and PRK Finite Element Simulations

Mathew Francis,<sup>1</sup> Pooja Khamar,<sup>2</sup> Rohit Shetty,<sup>2</sup> Kanchan Sainani,<sup>2</sup> Rudy M. M. A. Nuijts,<sup>3</sup> Bart Haex,<sup>4</sup> and Abhijit Sinha Roy<sup>1</sup>

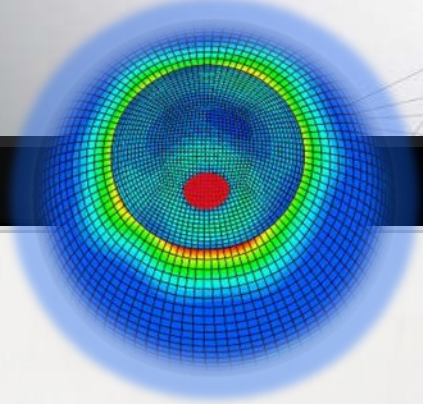
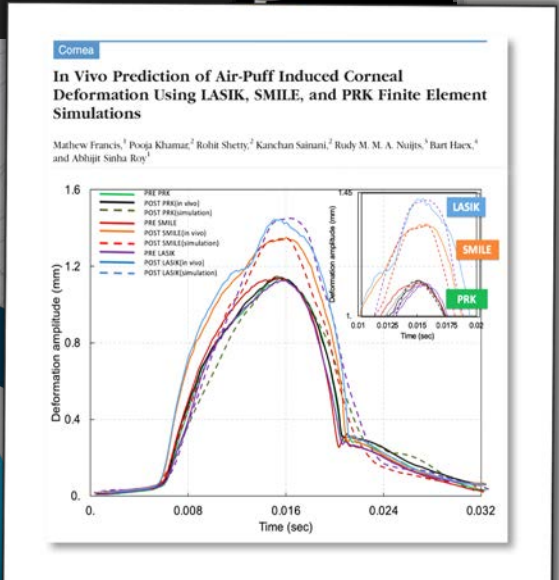




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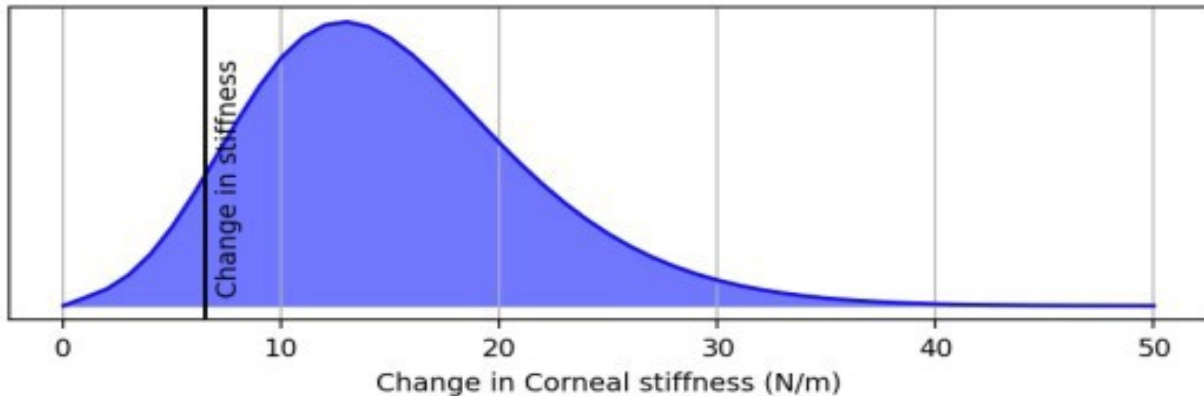
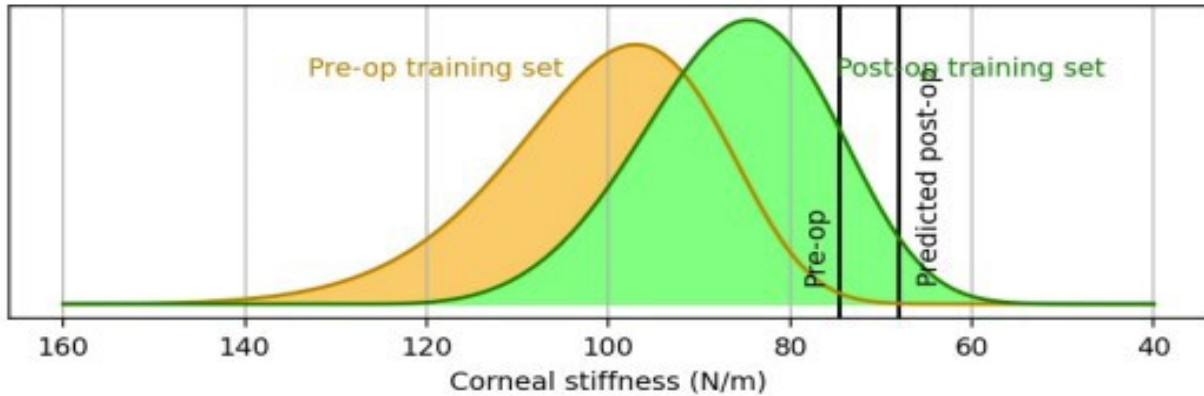
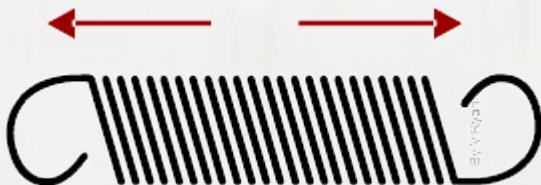
## REFRACTIVE SURGERY SIMULATION REPORT PRINTOUT

### Corneal Stiffness (N/m)

- Force required to move a body by 1 m
- Measures the amount of force required for a specific amount of change.

### Deformation Amplitude

- Measures change in cornea in response to set amount of pressure

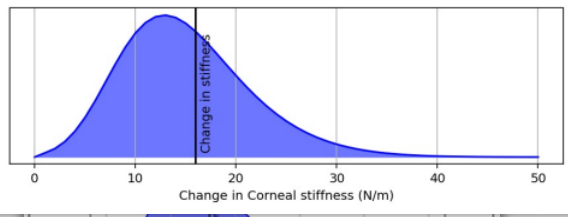
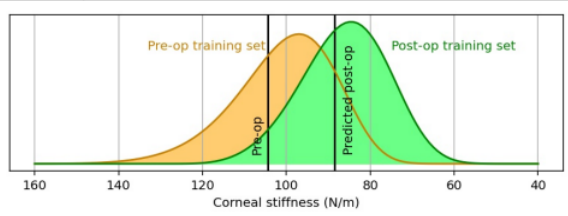
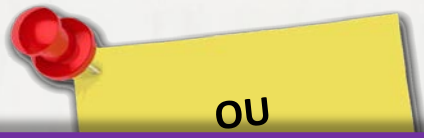
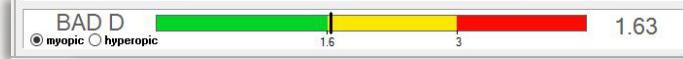
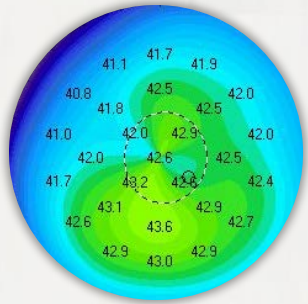


**Preoperative corneal stiffness: 74.63 N/m**  
**Predicted postoperative corneal stiffness: 68.17 [56.18, 80.15] N/m**  
**Predicted change in corneal stiffness: 6.46 N/m**

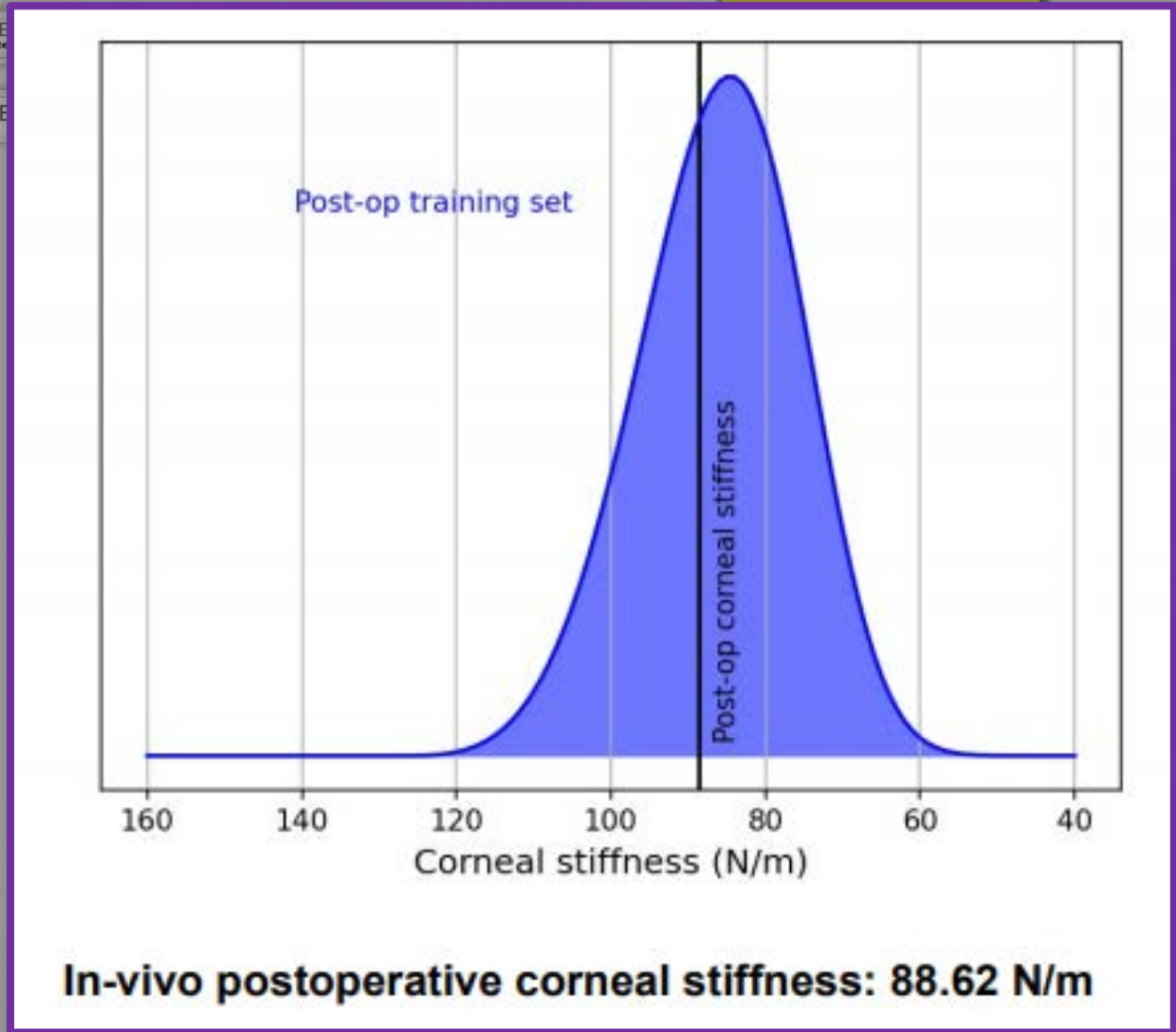
Change in Corneal stiffness (N/m)			
Spherical:	-2.5 D	Flap / Cap Thickness:	-NA-
Cylindrical:	-0.5 D	Flap / Cap Diameter:	-NA-
Axis:	180.0°	Optical Zone	6.0 mm

Axis: 180.0 Optical Zone 6.0 mm

-5.75DS/-0.25DC 165 (6/6)



Preoperative corneal stiffness: 104.46 N/m  
 Predicted postoperative corneal stiffness: 88.48 [77.62, 99.35] N/m  
 Predicted change in corneal stiffness: 15.97 N/m

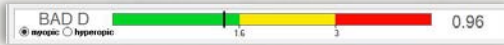
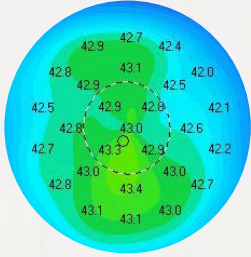


**In-vivo postoperative corneal stiffness: 88.62 N/m**

# PATIENT 1

OD

-2.25DS (6/6)



Normal



Abnormal

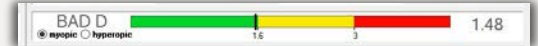
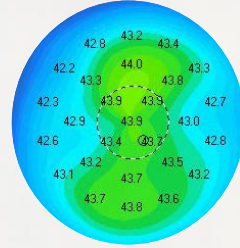


Suspicious



OS

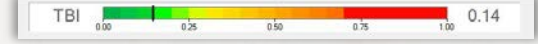
-2.25DS (6/6)



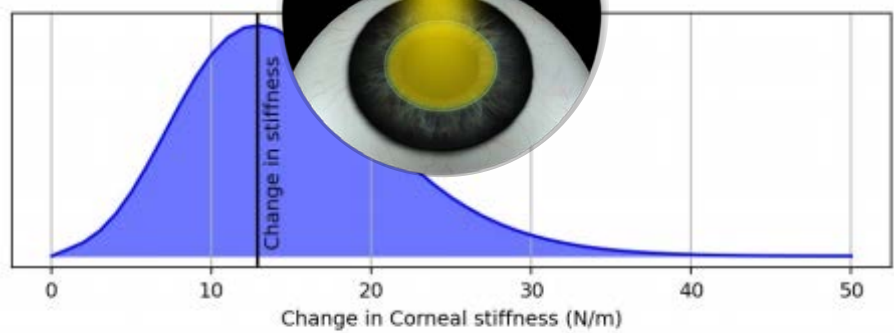
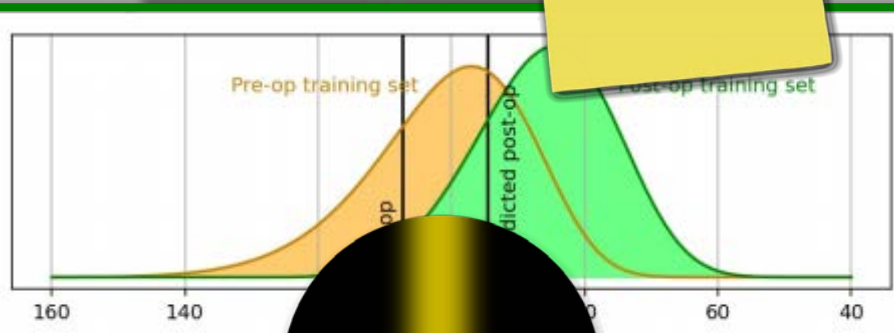
Normal



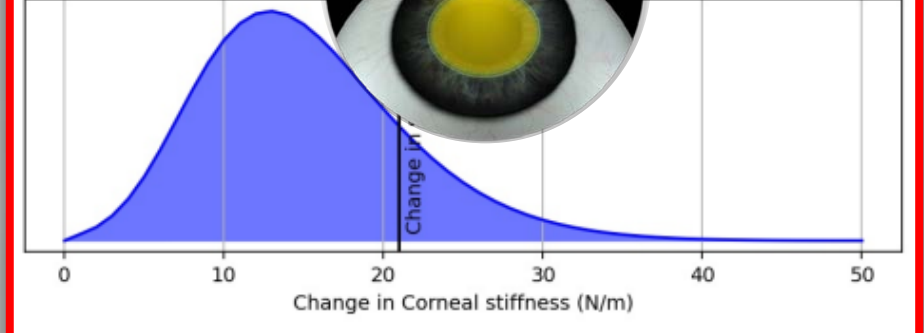
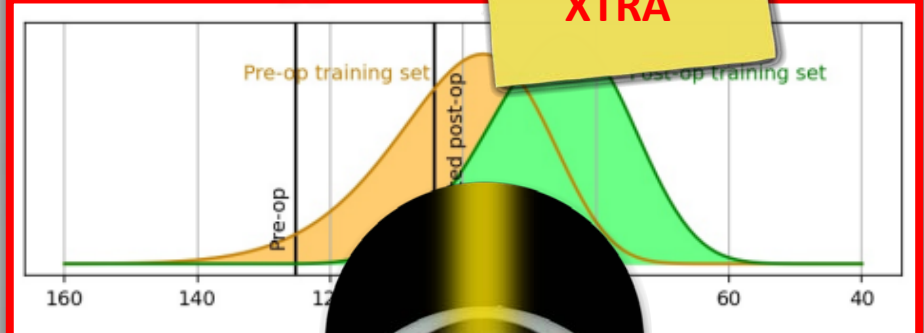
Abnormal



Normal



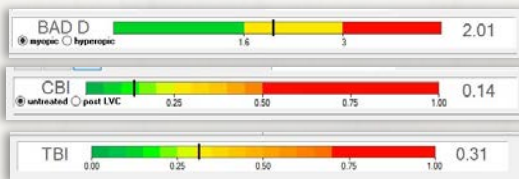
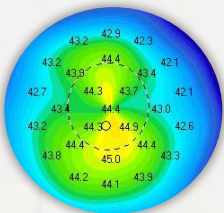
Preoperative corneal stiffness: 107.4 N/m  
 Predicted postoperative corneal stiffness: 94.6 [83.73, 105.46] N/m  
 Predicted change in corneal stiffness: 12.81 N/m



Preoperative corneal stiffness: 125.28 N/m  
 Predicted postoperative corneal stiffness: 104.36 [93.41, 115.31] N/m  
 Predicted change in corneal stiffness: 20.92 N/m

# PATIENT 2

**-5.00DS/-1.25DC@15 (6/6)**

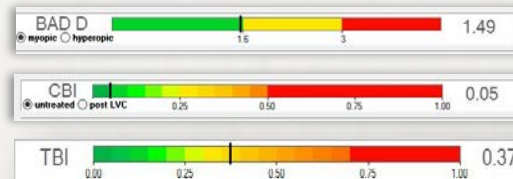
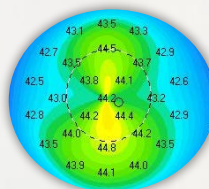


Suspicious

Normal

Suspicious

**-6.00DS/-1.25DC@70 (6/6)**



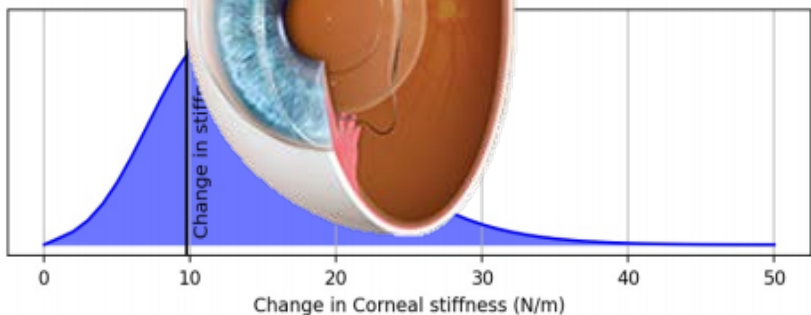
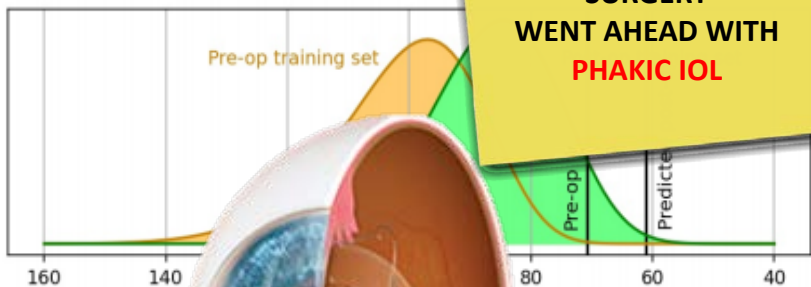
Normal

Normal

Suspicious



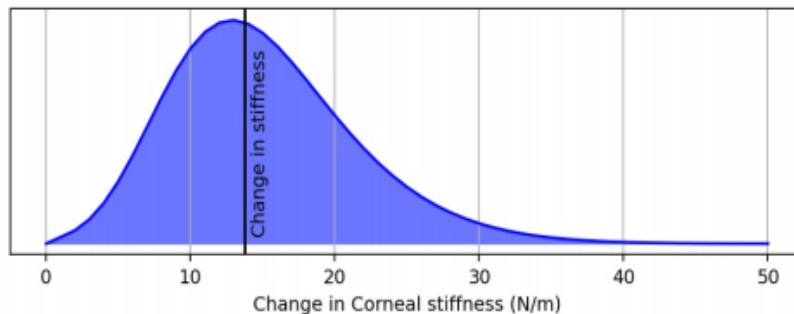
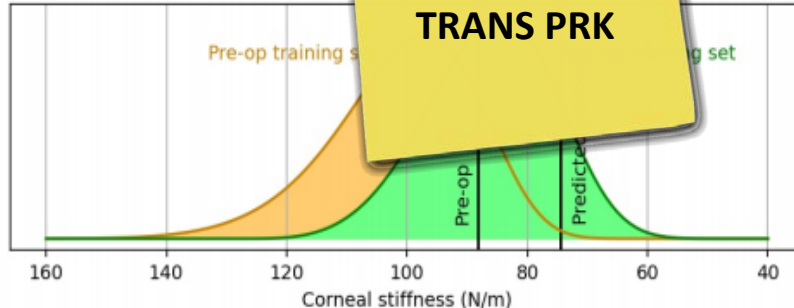
**DEFERRED LASER BASED REFRACTIVE SURGERY WENT AHEAD WITH PHAKIC IOL**



Preoperative corneal stiffness: 70.81 N/m  
 Predicted postoperative corneal stiffness: 61.06 [49.39, 72.73] N/m  
 Predicted change in corneal stiffness: 9.74 N/m



**OU SMILE/LASIK/ TRANS PRK**



Preoperative corneal stiffness: 88.2 N/m  
 Predicted postoperative corneal stiffness: 74.48 [62.84, 86.12] N/m  
 Predicted change in corneal stiffness: 13.72 N/m



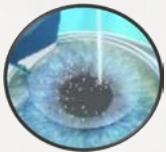
# MATERIALS AND METHODS

**STUDY DESIGN**  
OBSERVATIONAL STUDY

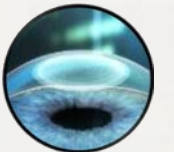
**STUDY SETTING**  
NARAYANA NETHRALAYA,  
BENGALURU

**STUDY RECRUITS**  
(529 eyes)

**STUDY RECRUITS**  
(529 eyes)



**LASIK**  
(300 EYES)

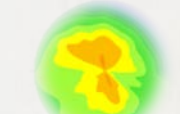


**ReLEx SMILE**  
(120 EYES)

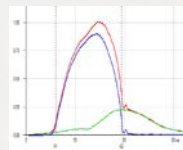
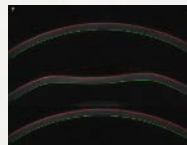
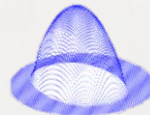


**PRK**  
(60 EYES)

**PREOPERATIVE ASSESSMENT**



**PENTACAM HR**



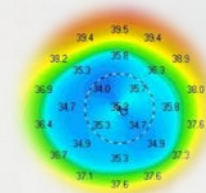
**Corvis ST DEFORMATION DATA & VIDEO**

**SOFTWARE RUN**

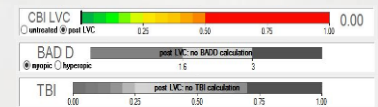


**AcuSimX**

**POST OPERATIVE VALIDATION**



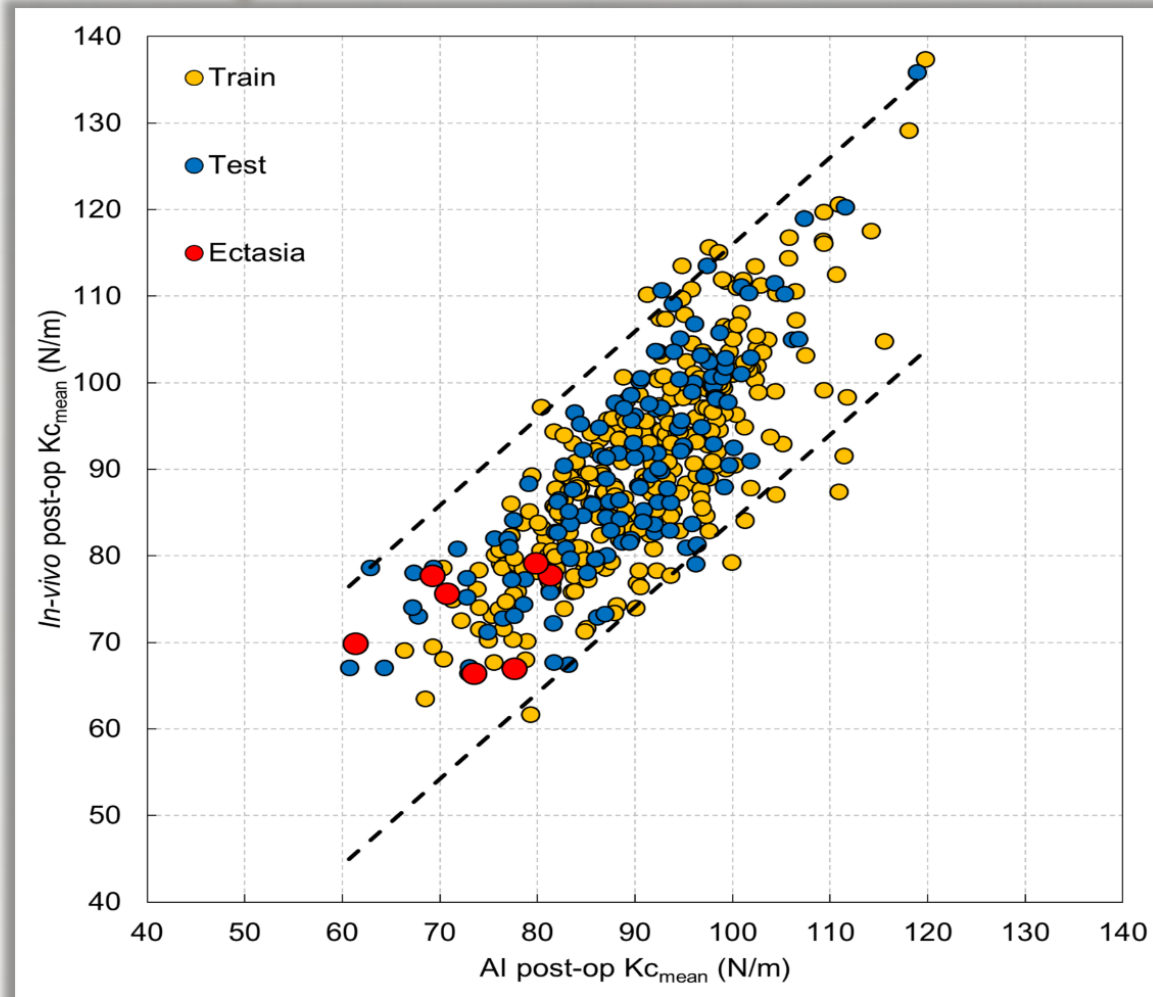
**PENTACAM HR**



**CORNEAL BIOMECHANICS**



# Results



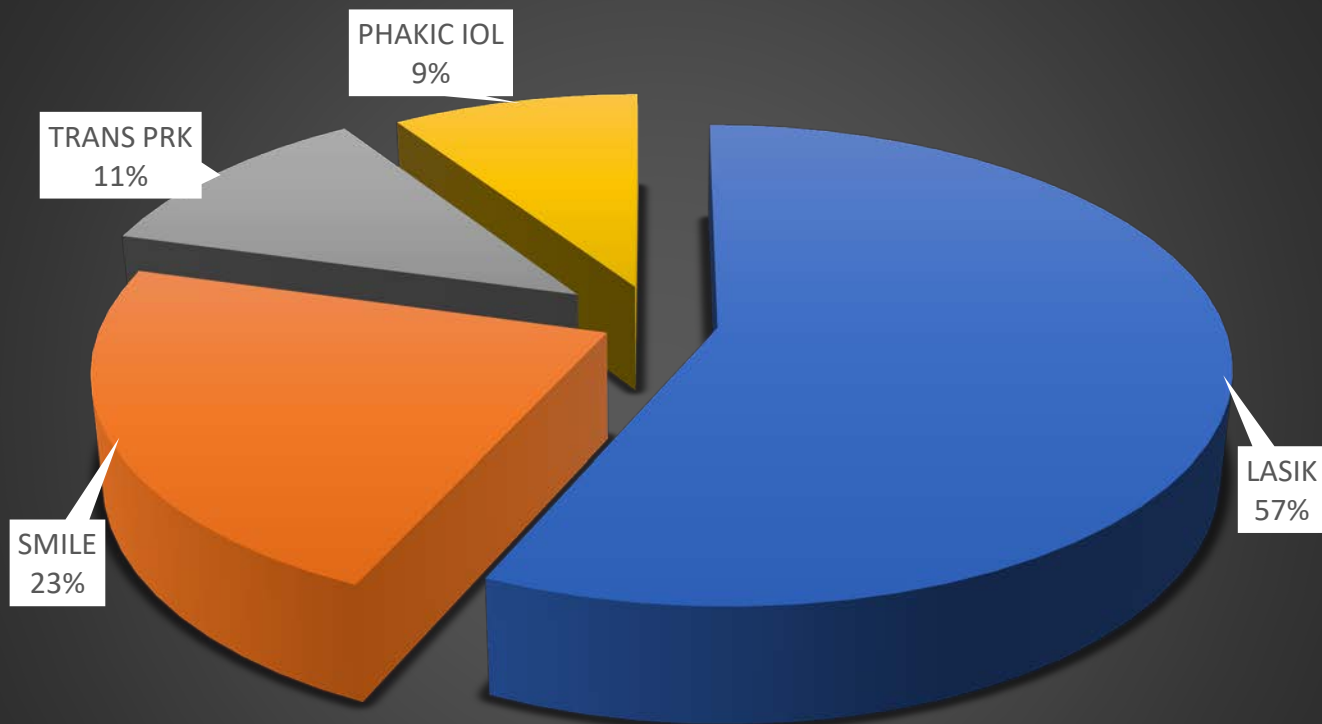
AI build using **529 eyes** collected from **multiple centres around the world**

**Mean absolute error** was **6.24** and **6.47 N/m** in train and test cohort

**Successfully predicted** post-op biomechanics of **7 ectasia eyes**

Predictive simulation in just **20 keystrokes**

## NUMBER OF EYES THAT UNDERWENT REFRACTIVE SURGERY SIMULATION



■ LASIK ■ SMILE ■ TRANS PRK ■ PHAKIC IOL



# SOFTWARE IN BETA TESTING PHASE AT 20 CENTRES ACROSS THE GLOBE



## WHAT WAS KNOWN:



- ✓ Post operative excessive biomechanical weakening can lead to ectasia in a normal eye
- ✓ Currently, here is NO TOOL to predict the post operative outcomes.



## WHAT ACUSIMX ADDS:



- ✓ **FIRST AI BASED** simulation software for refractive surgery in the world, which predicts the postoperative weakness & helps decide on refractive surgeries
- ✓ First software to include India specific data
- ✓ Surgery specific prediction models
- ✓ In vivo simulation matches post operative corneal stiffness Excellent ICC (**>0.9 OVERALL**)

# THE NEXT STEP...

Patient Examination Display Settings External software

Load

Scan

New Full Sequence →

- ✓ Full Sequence Examination Selection
- Fast Screening Report
- General Overview
- 1 Large Color Map
- 4 Maps Selectable
- 4 Maps Refractive
- 4 Maps Topometric
- 4 Maps Chamber
- Scheimpflug Images
- Scheimpflug Image Overview
- Iris Image
- Virtual Eye
- Tomography
- Corneal Optical Densitometry
- Topometric/KC-Staging
- Belin ABCD Progression Display
- Refractive
- Pachymetric
- Holladay Report
- Holladay EKR Detail Report
- Corneal Power Distribution
- Cataract Pre-OP
- Zernike Analysis
- Belin/Ambrósio Enhanced Ectasia Display
- Fourier Analysis
- Corneal Rings
- Contact Lens Fitting
- CSP Report
- 3D pIOL Simulation and Aging Prediction
- Show 2 Exams
- Show 2 Exams Pachymetric
- Show 2 Exams Topometric
- Show 2 Exams Scheimpflug Images
- Compare 2 Exams
- Compare 4 Exams
- Compare 2 Exams Scheimpflug Images

AXL-Scan

IOL Calculator

Aberrometry

Visual Performance

Full Sequence Overview

All Displays and Configuration >

AcuSimX

Contrast Normal

Adjust Image

	Show	Fill
Cornea Front	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Cornea Back	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Iris	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Lens Front	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Lens Back	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Scale	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Cutout Width: 60°

Cutout Pos: 270°

Normalize Animate

A. C. Depth (Ext.): Pupil Dia:

Enter IOP IOP(Sum): HWTW:

Axial Length: SNR(Ax.Len.)

Corneal Thickness

NARAYANA NETHRALAYA

\* Price of the Software

\* Deal With Oculus –incorporation of software in Pentacam



*Thank you*

NARAYANA  
NETHRALAYA  
— YOUR FAITH SHALL HEAL YOU! —