Corneal biomechanics

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Aiming to →

Understanding biomechanical properties and definitions

Biomechanics of human cornea

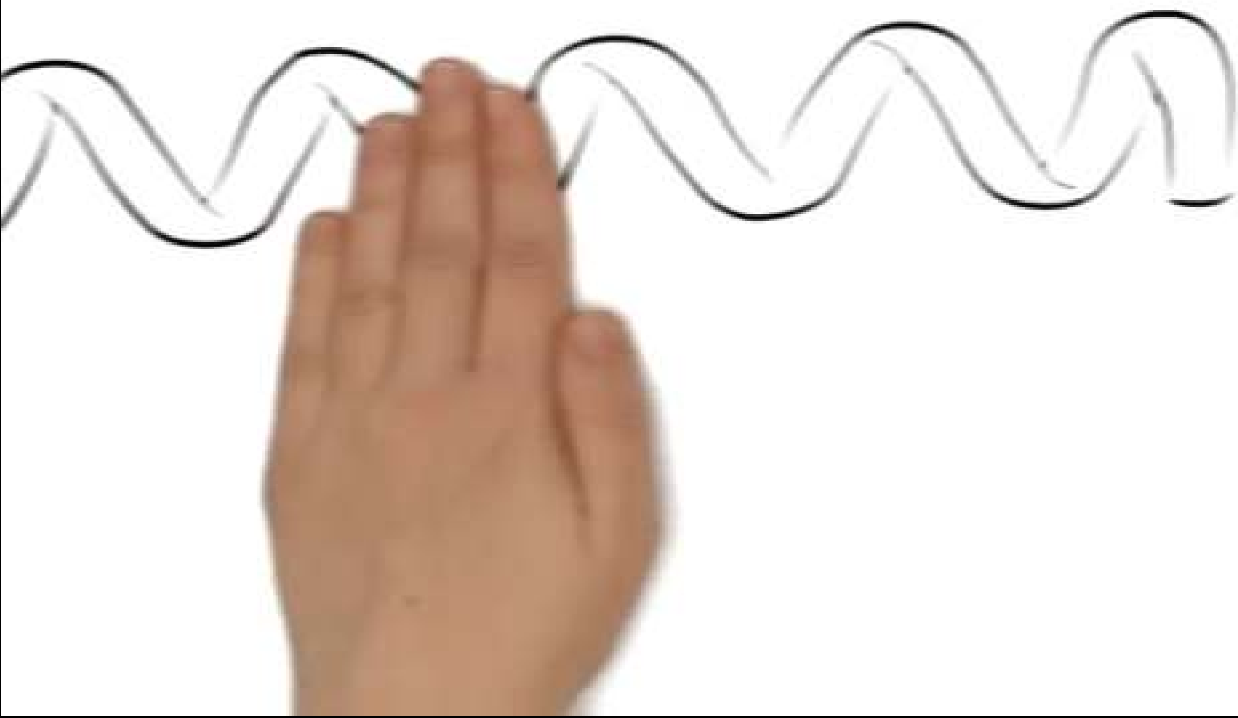
Methods used for corneal biomechanics assessment

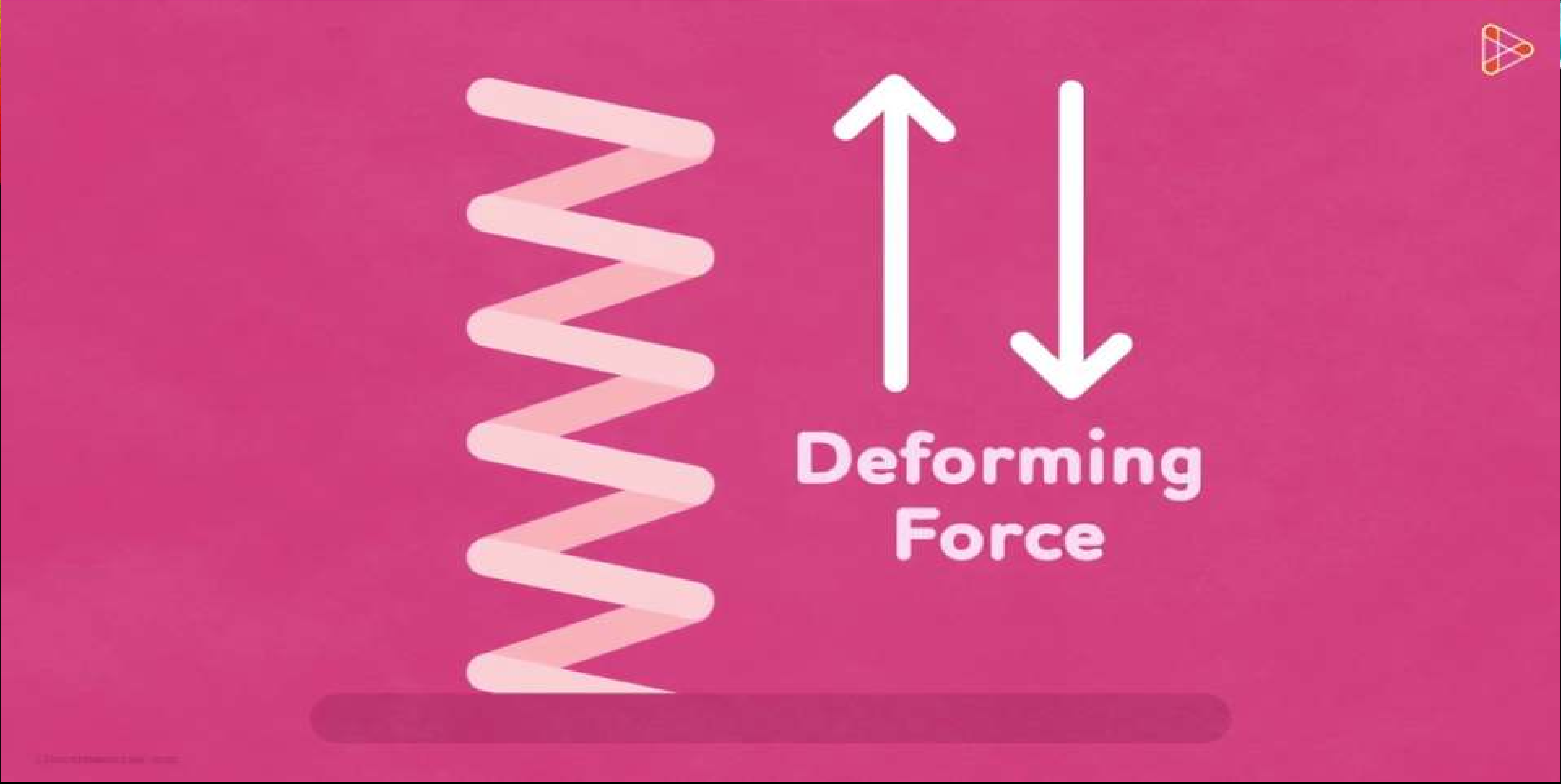
Clinical application of biomechanics

BIOMECHANICAL DEFINITIONS

- The response of a biological tissue to **a force**.
- Depends on the **biochemical and physical nature** of the components present and their relative amounts.

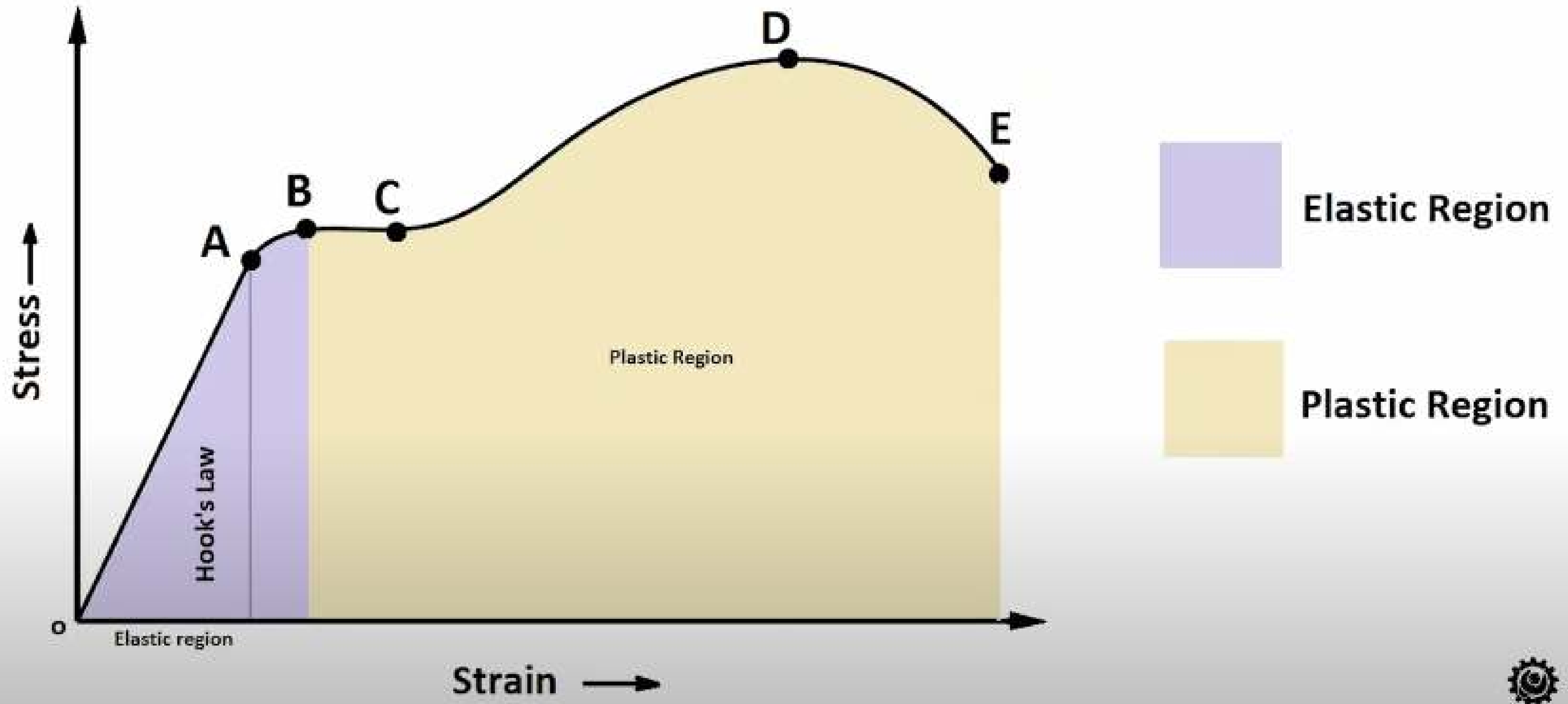
Elasticity




Deforming
Force

Viscosity

Stiffness


Stress
Strain
o
A
B
C
D
E
Hook's Law
Elastic region
Plastic Region
Elastic Region
Plastic Region

Stiffness

The cornea is considered to be

viscoelastic

Stiff but , still flexible

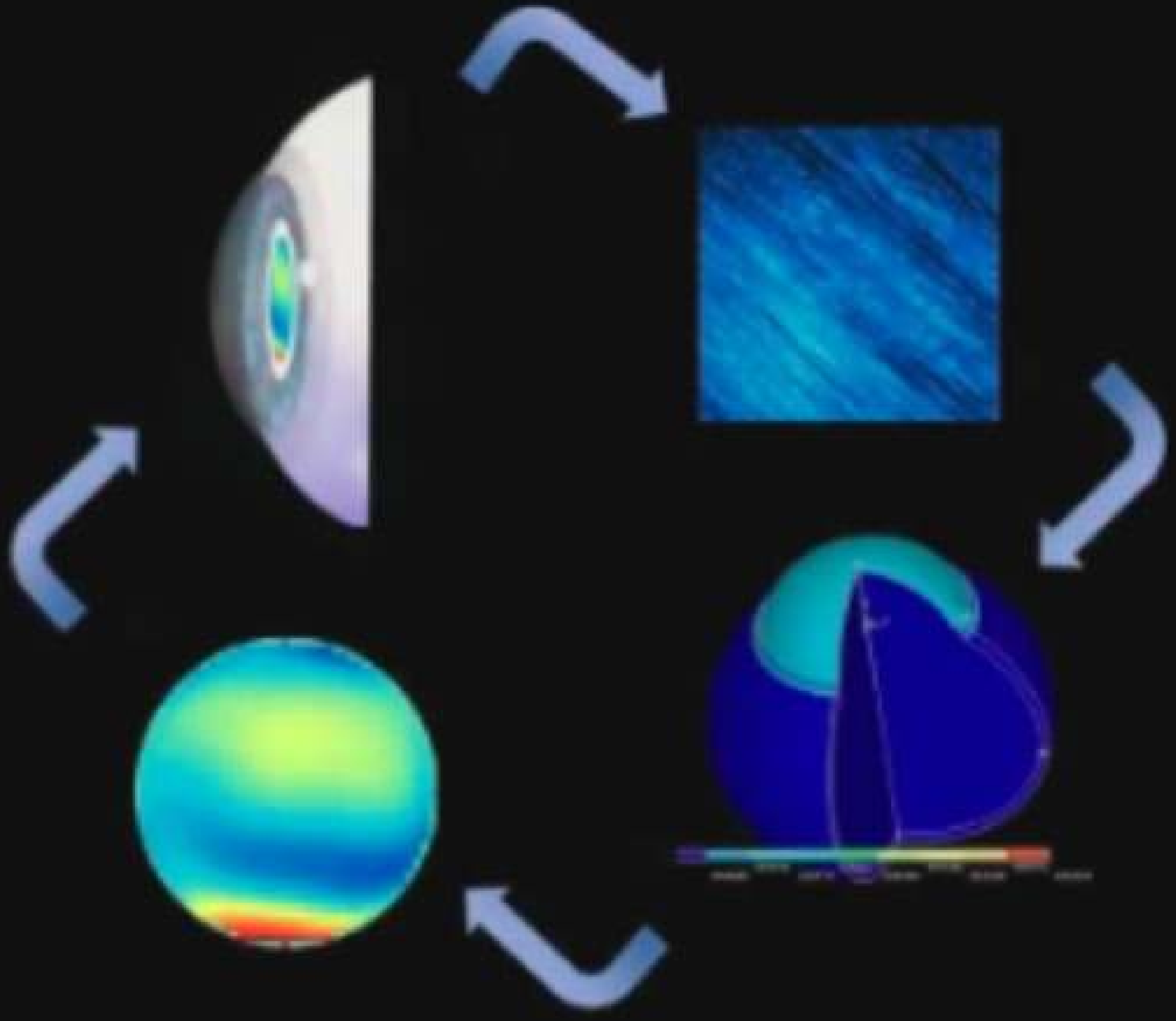
FACTORS DETERMINING CORNEAL BIOMECHANICAL PROPERTIES

- **Extracellular matrix components**

glycoproteins, collagen and enzymes, providing biochemical and structural support to the surrounding cells

Collagen and elastin are responsible for the strength and elasticity of a tissue, while the ground substance is responsible for the viscoelastic properties

- **Hydration**
- **Environmental factors**
- **Hormonal fluctuations**
- others



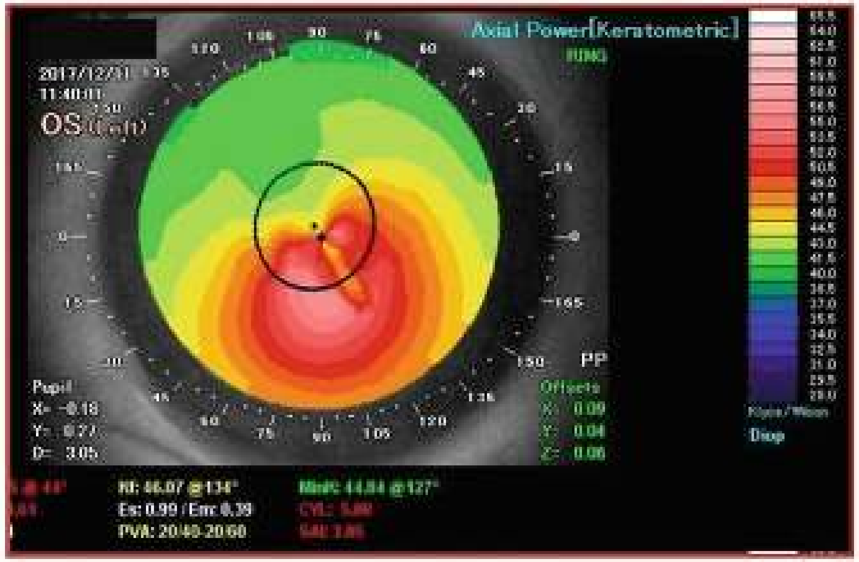
The mechanical structure of the cornea determines corneal integrity and shape...

... and therefore optical and visual quality

AVAILABLE INVESTIGATIONS FOR **CORNEA**

Placido-based

TMS 5 (Tomey)



Placido-based

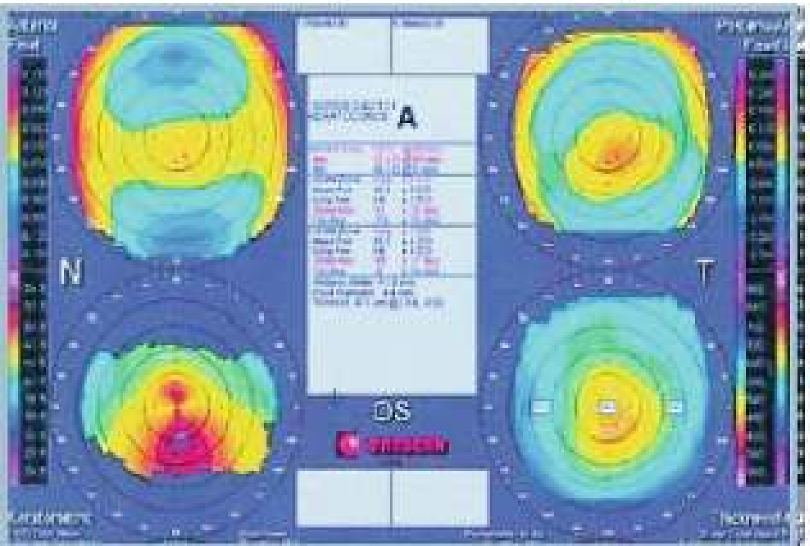
Only anterior corneal surface

Corneal tomography

Both anterior & posterior corneal surfaces

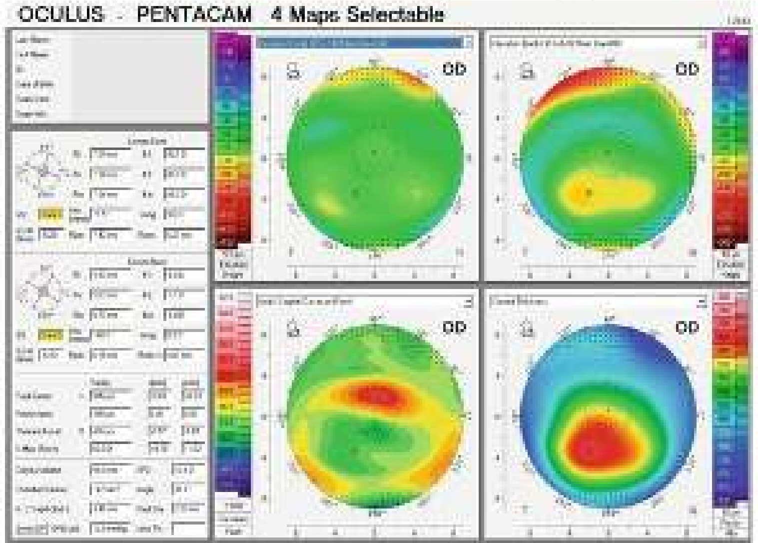
Slit-scanning

Orbsan (Bausch + Lomb)



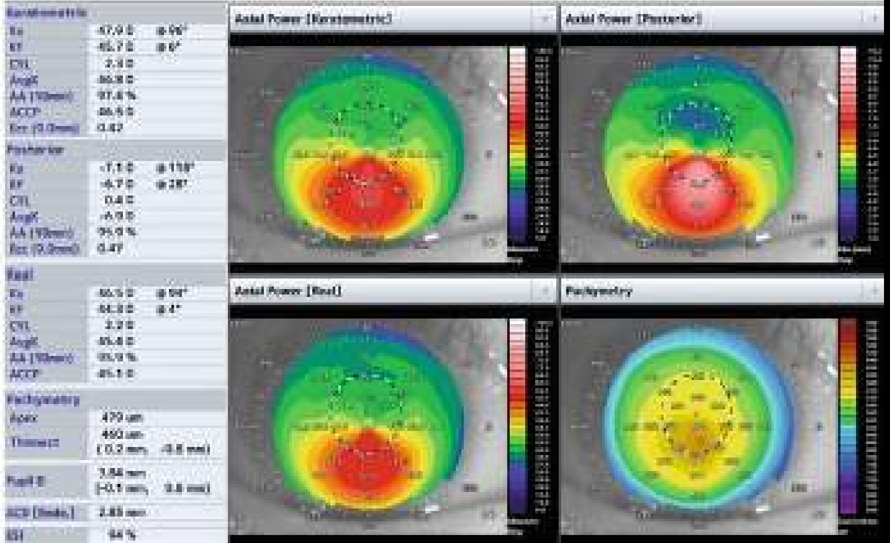
Scheimpflug-based

Pentacam HR (Oculus)



OCT-based

CASIA SS-2000 (Tomey)



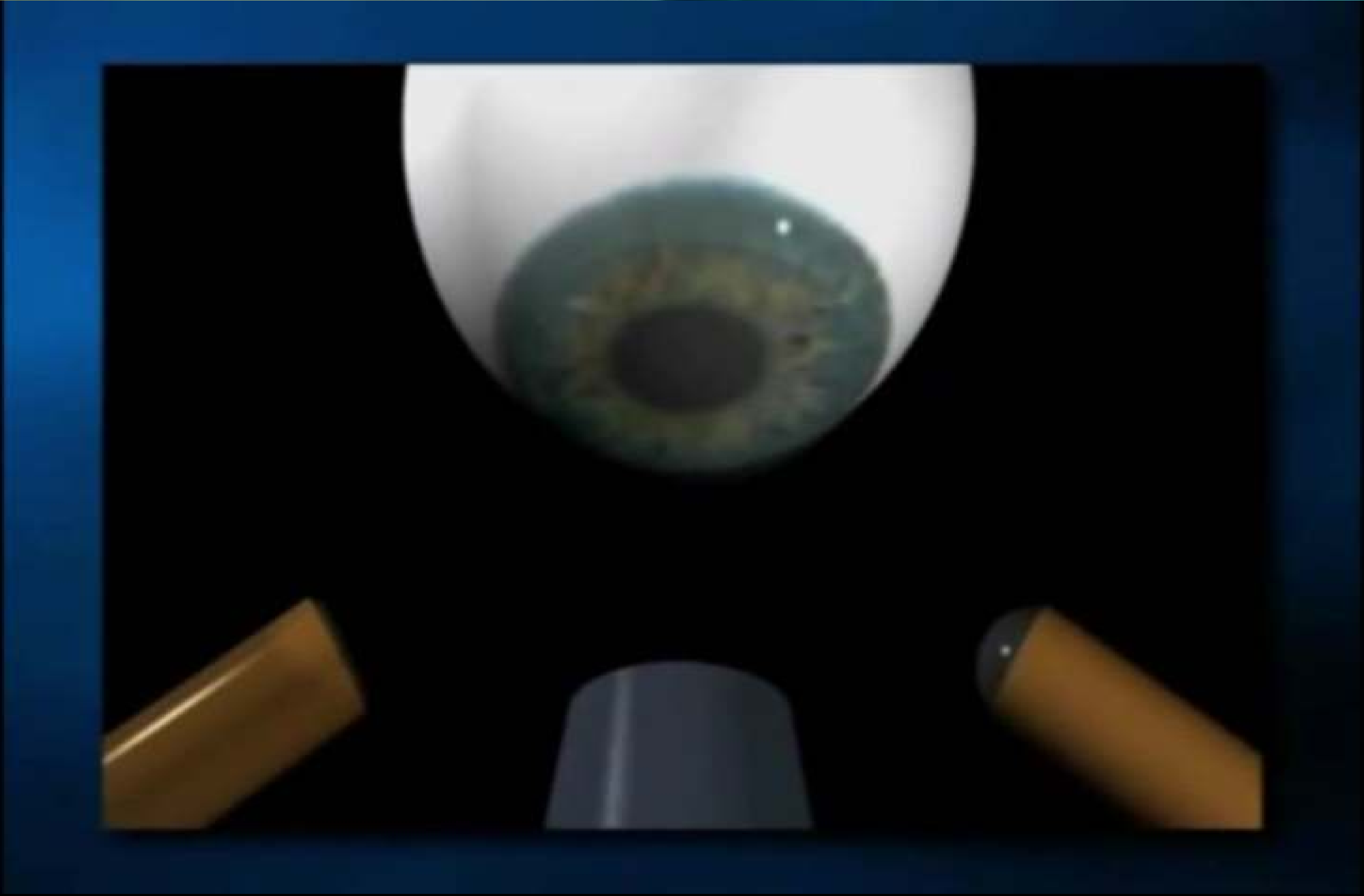
METHODS USED FOR CORNEAL BIOMECHANICS ASSESSMENT

ORA

CORVIS ST

Technique	In-vivo/ex-vivo	Measurement variables	Detection of biomechanical change
St			Stress–strain behavior of cornea
In			Corneal stiffness after CXL
Sp in			Corneal deformation, IOP detection
OR		nd	Parameters for detecting sub clinical keratoconus
CC		ation	Detects ectatic diseases
Go to		g force	IOP detection
Brillouin spectroscopy	In-vivo	3D Brillouin modulus	Brillouin modulus changes after CXL and in keratoconus

and dynamic corneal deformation imaging by air puff in vivo



ORA

Corneal hysteresis

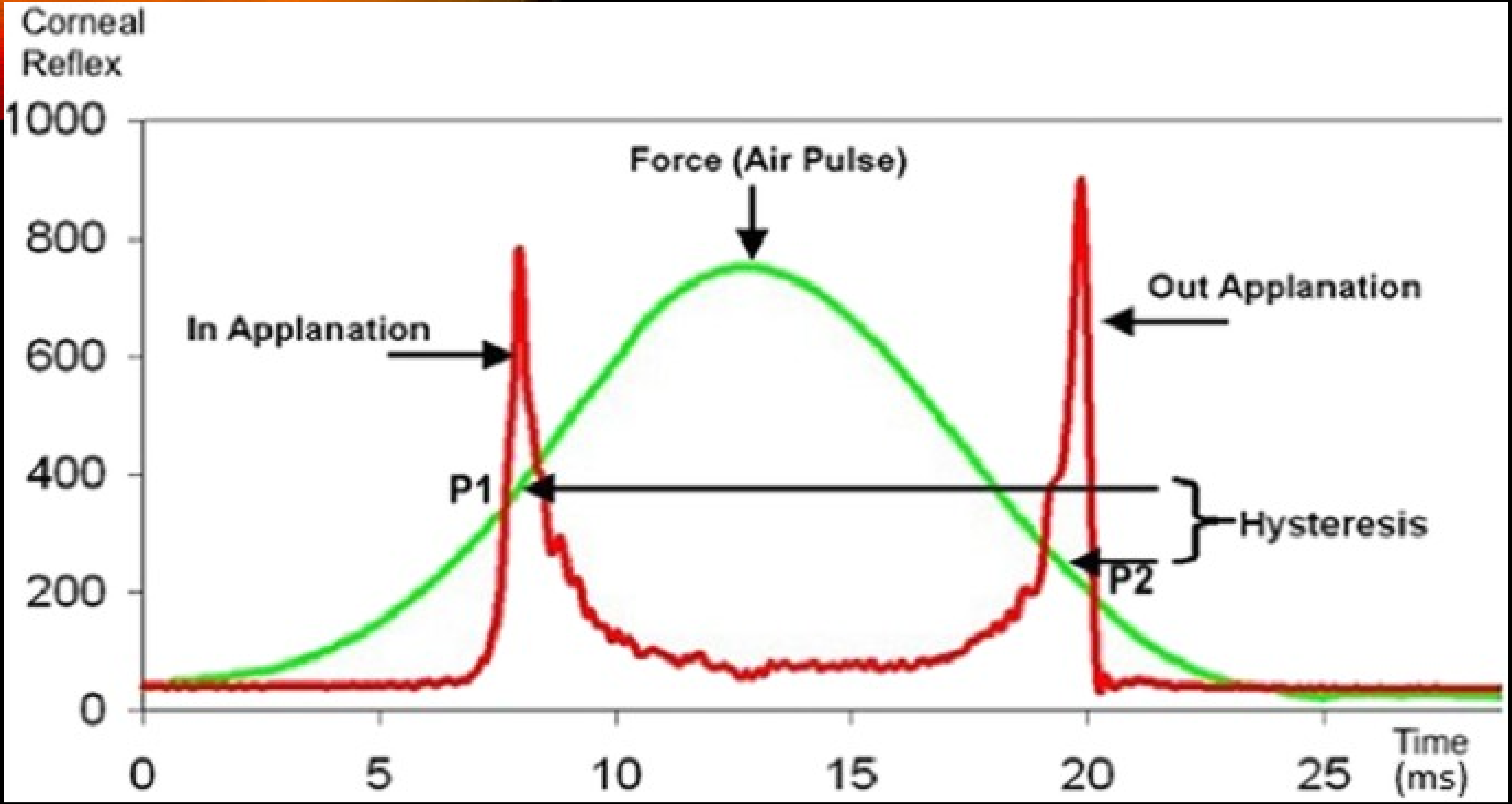
is the difference between the P1 and P2 values

corneal resistance factor

calculated according to the formula:

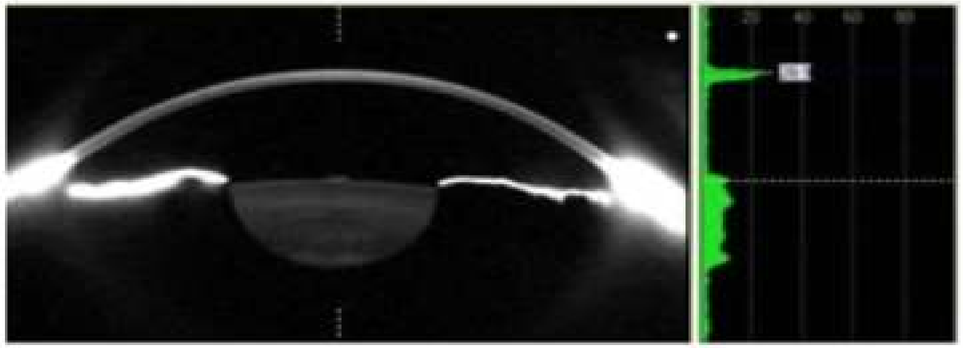
$$a\,[P1 – 0.7P2] + d$$

where *a* and *d* are calibration and regression constants to maximize correlation with central corneal thickness

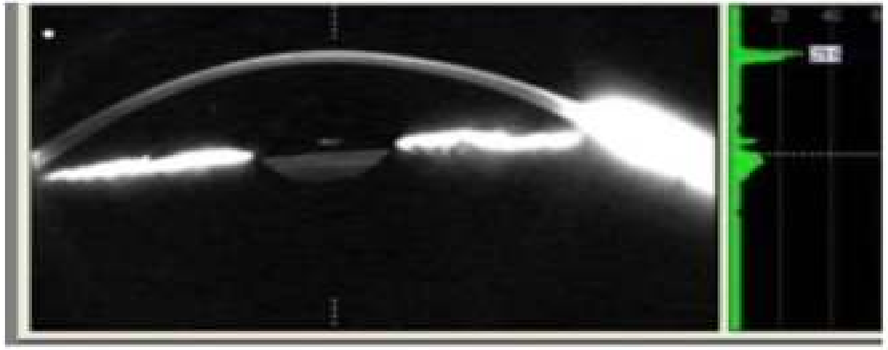


Corneal
Reflex
1000
800
600
400
200
0
Force (Air Pulse)
In Applanation
Out Applanation
P1
P2
Hysteresis
0
5
10
15
20
25
Time
(ms)

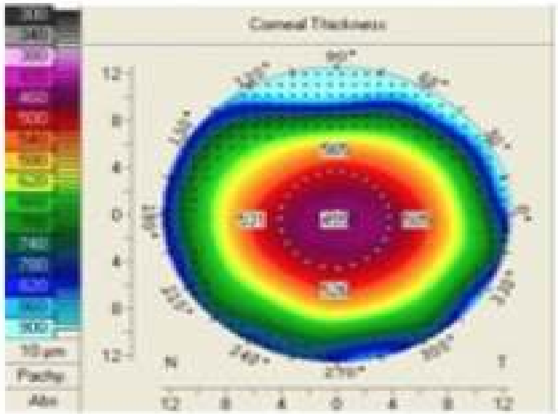
Classifying Corneal Pathologies



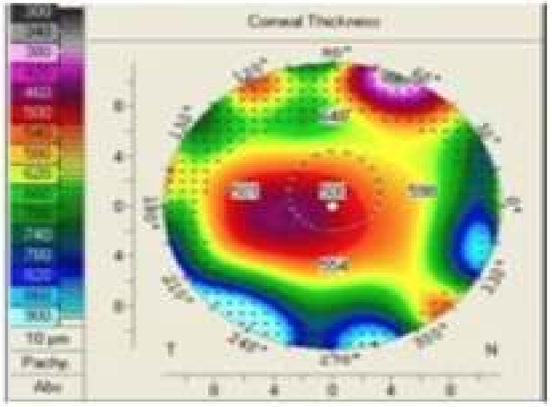
Thin Cornea with no ectasia



Thin Cornea with Keratoconus



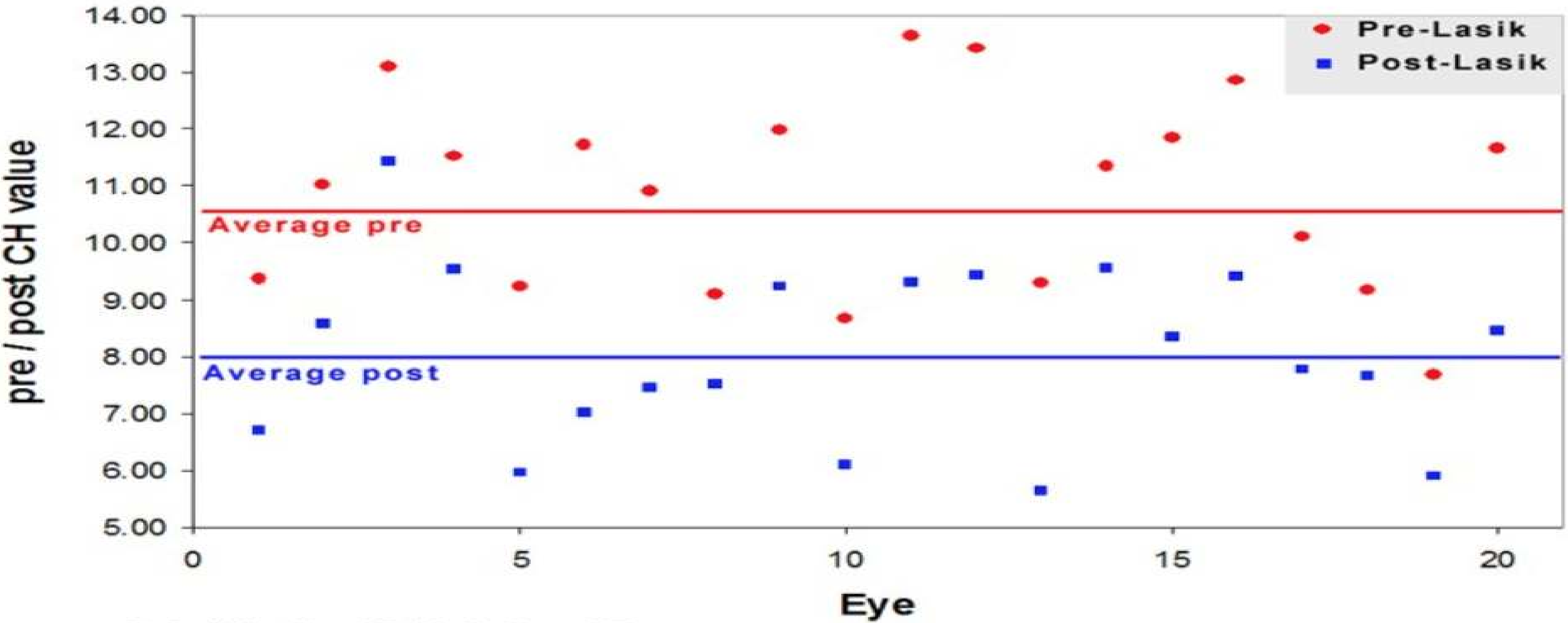
CH=11.2
CRF=10.8



CH=8.1
CRF=7.9

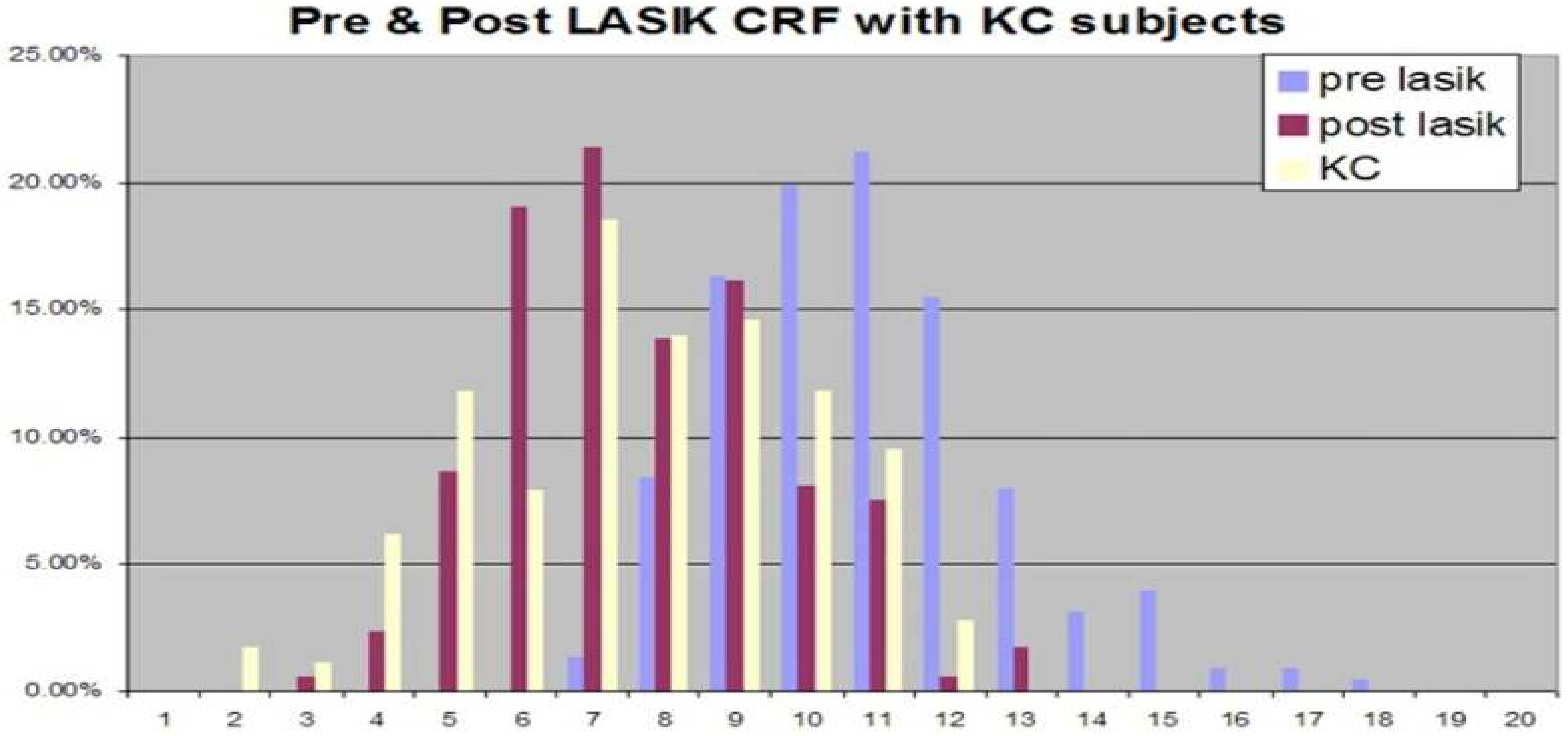
Ocular Response Analyzer

Pre / Post Lasik



Ocular Response Analyzer

Predicting Ectasia Risk



EVEN THOUGH STUDIES HAVE REPORTED **CH AND CRF** TO BE LOWER IN **KC** COMPARED TO HEALTHY CORNEAS

-

A CONSIDERABLE OVERLAP IN THE DISTRIBUTIONS OF BOTH PARAMETERS WAS OBSERVED

===============================

THE **SENSITIVITY** AND **SPECIFICITY** FOR KC DIAGNOSIS ARE RELATIVELY WEAK

SO , WE NEED MORE **PARAMETERS**

CorVis ST

What is it?

- Air Tonometer
- Ultra high speed Scheimpflug camera

How does it work?

- Air puff indents cornea
- Video 4333 frames/sec
- Calculates a range of output measurements
- Parameters describe *in vivo* biomechanics

Corvis ST – Parameters

1st Appl[illegible]	[illegible] air puff (in milliseconds). The length of the applanation at this moment appears in parenthesis (in millimeters).
Highest [illegible]	[illegible]mum concavity during the air puff (in milliseconds). The length of the distance between the two peaks of the [illegible] (in millimeters).
2nd App[illegible]	[illegible]r puff (in milliseconds). The length of the applanation at this moment appears in parenthesis (in [illegible]
Maximur[illegible]	[illegible] deformation during the air puff.
Wing Dis[illegible]	[illegible]wo peaks of the cornea at this instant (in millimeters).
Maximur[illegible]	[illegible]se (in meters per seconds [m/s]).
Maximur[illegible]	[illegible] phase (in meters per seconds [m/s]) .
Curv[illegible]	[illegible]
Curv[illegible]	[illegible]ng the air puff (in millimeters).
Cornea Thickness	Measurement of the corneal thickness (in millimeters).
Integ[illegible]	[illegible]
Defo[illegible] or 2 [illegible]	[illegible]r side of center with maximum value just prior to 1st applanation.
IOP	[illegible]
bIOP	Biomechanically-corrected IOP

1st Applanation

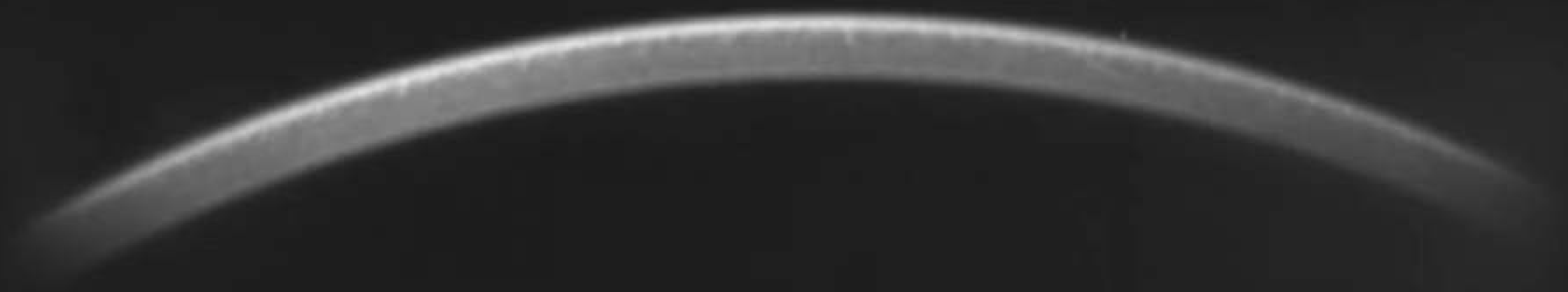
2nd Applanation

Highest Concavity

Integrated Inverse Radius

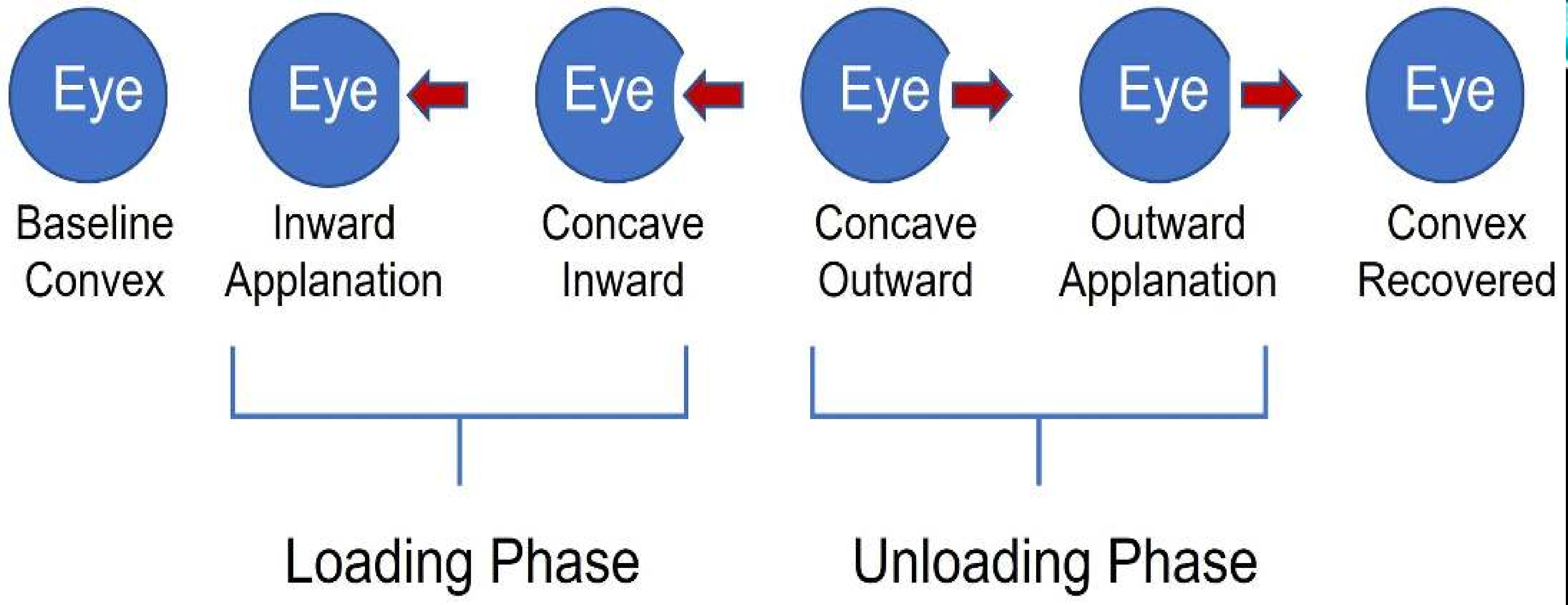
Deformation Amplitude Ratio 1 or 2 mm

OCULUS Corvis® ST



Viewable biomechanical analysis with more than 4,000 images per second.

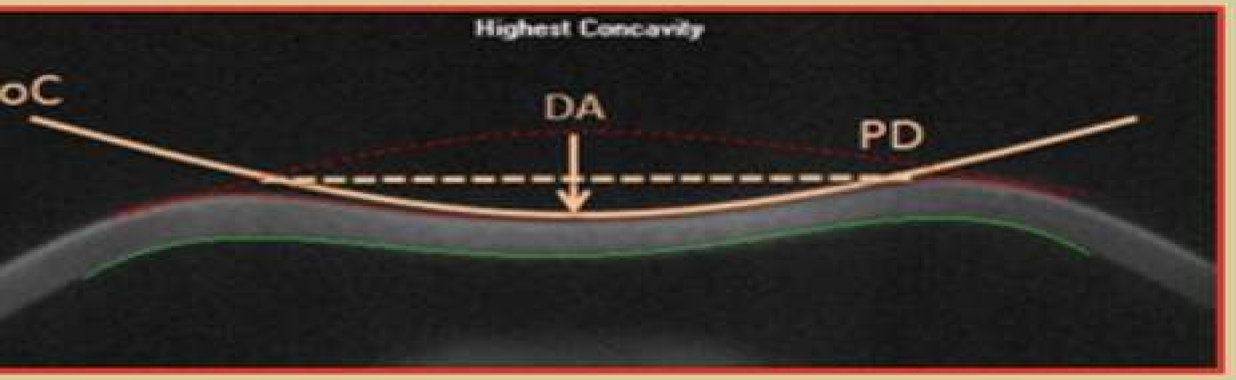
OCULUS®



- **Figure 1. Schematic diagram of air puff loading of the cornea with red arrows indicating direction of movement. The initial phase is Baseline Convex prior to deformation. The Loading Phase includes deformation through Inward Applanation (flattening) and into Concave phase in the Inward direction. The Unloading Phase includes initiation of recovery from Concave phase in the Outward direction through Outward Applanation to the Convex shape Recovered.**

CorVis ST - Parameters

- Applanation1
  - Time
  - Length
  - Velocity



- Highest Concavity
  - Deformation Amplitude
  - Radius of Curvature
  - Peak Distance

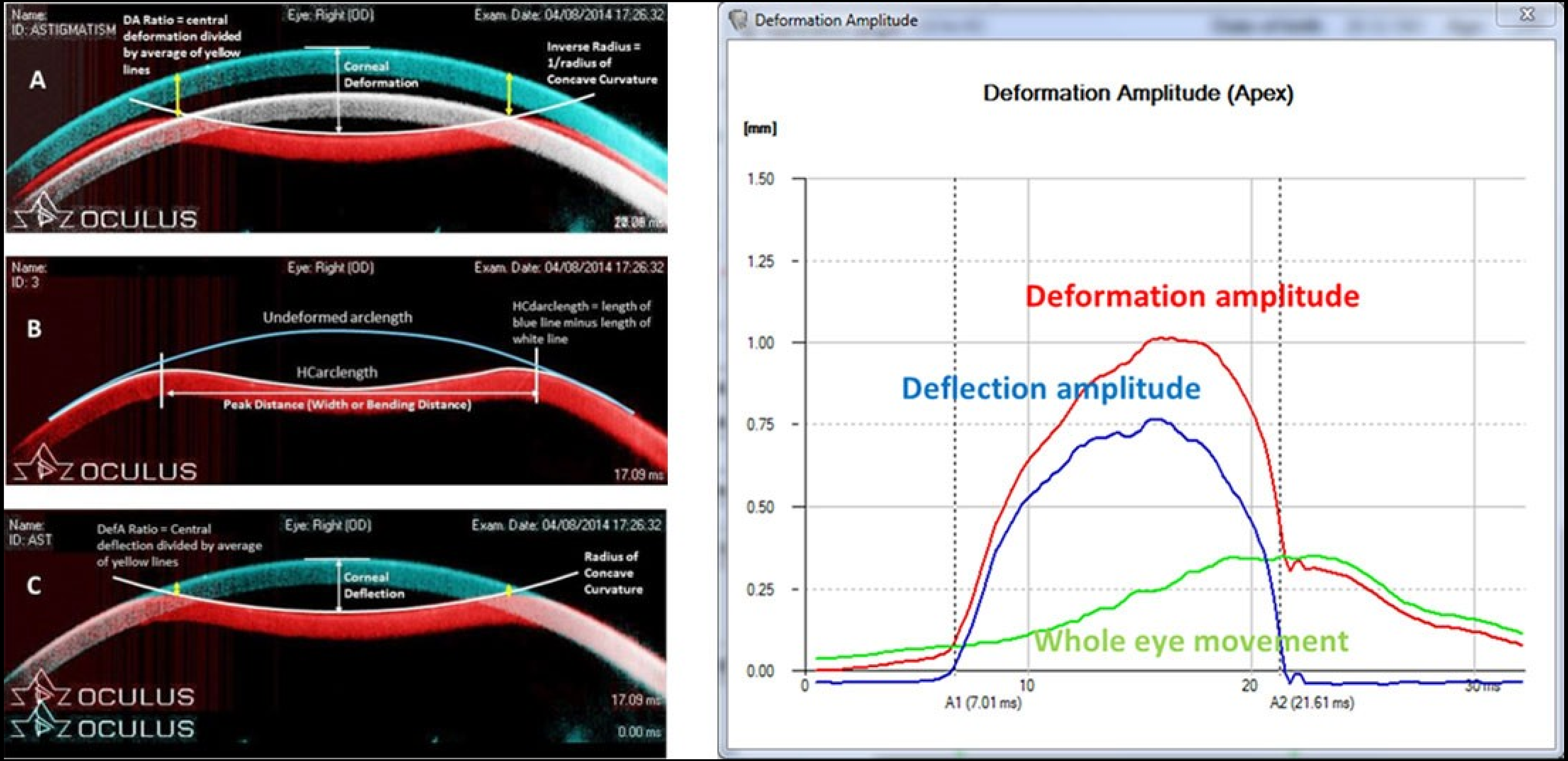
- Applanation2
  - Time
  - Length
  - Velocity

CORVIS ST - parameter

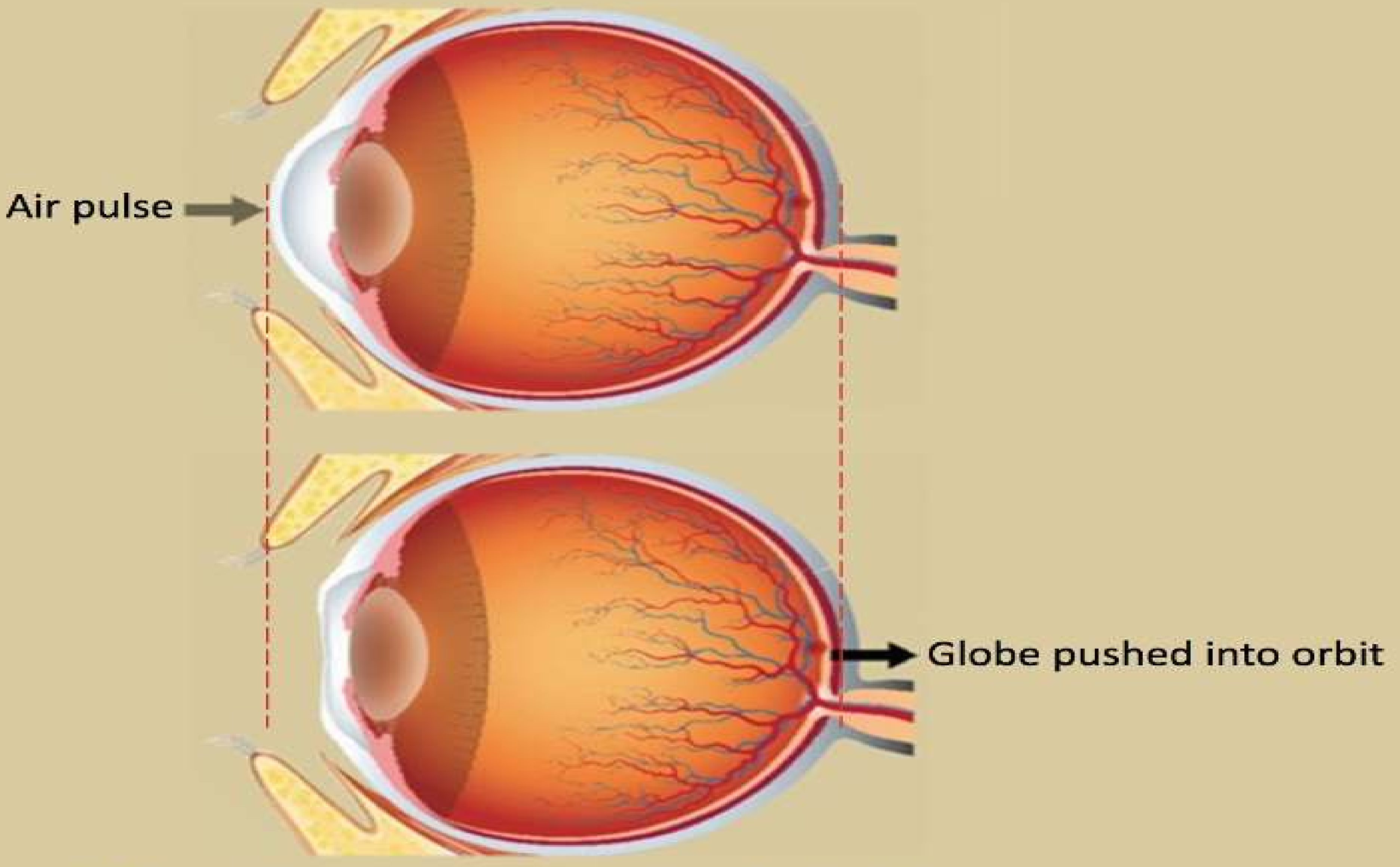
- Dynamic corneal Response Parameters
  - Deformation Amplitude
  - DA ratio 2mm
  - Integrated Radius

- **CBI_LVC**: Corneal stability after laser vision correction

CORVIS ST – DCR - DA

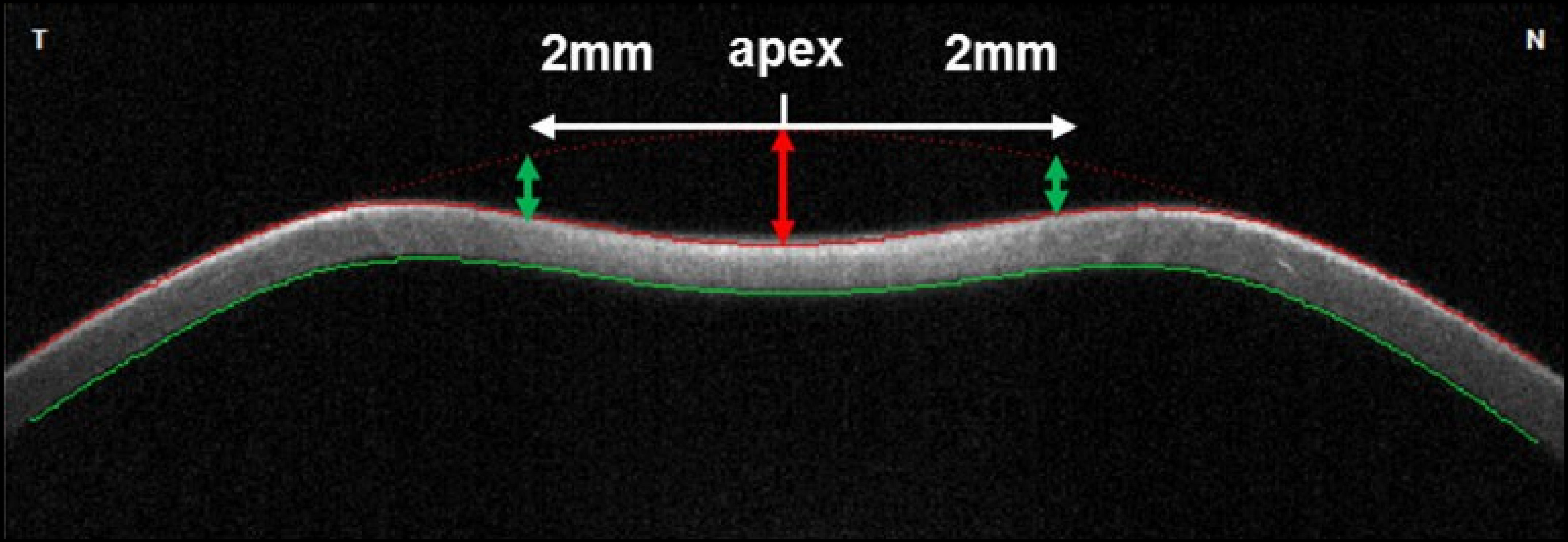


Response to an air-pulse is not purely corneal

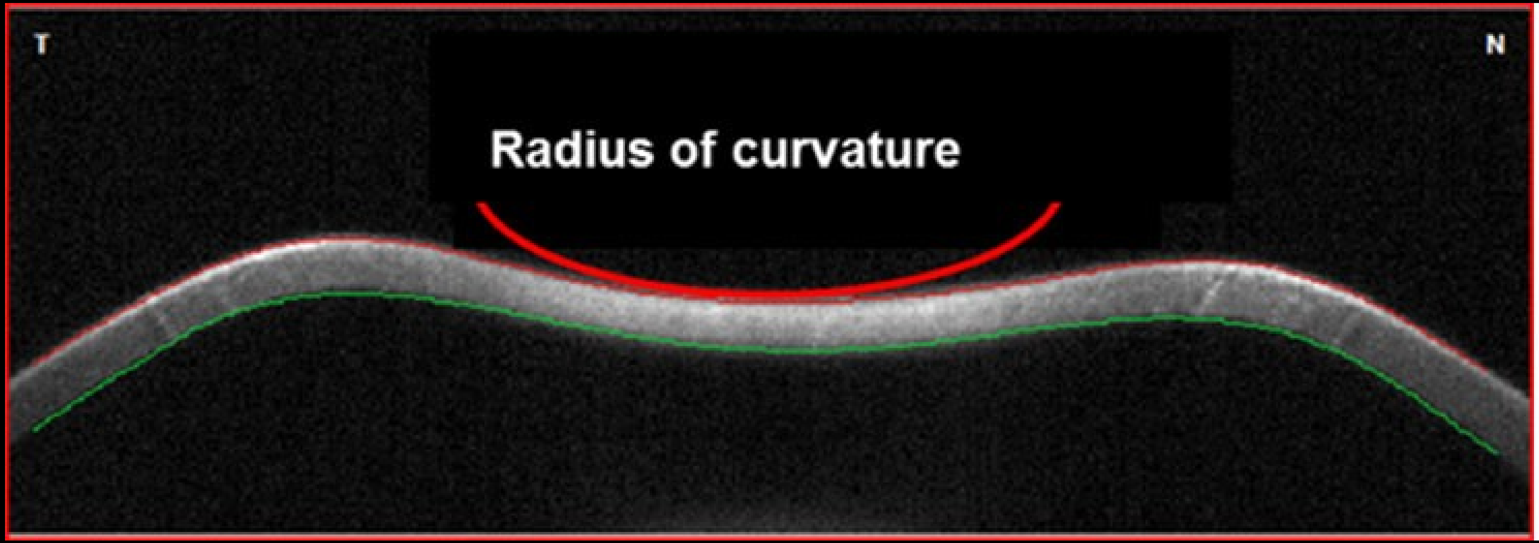


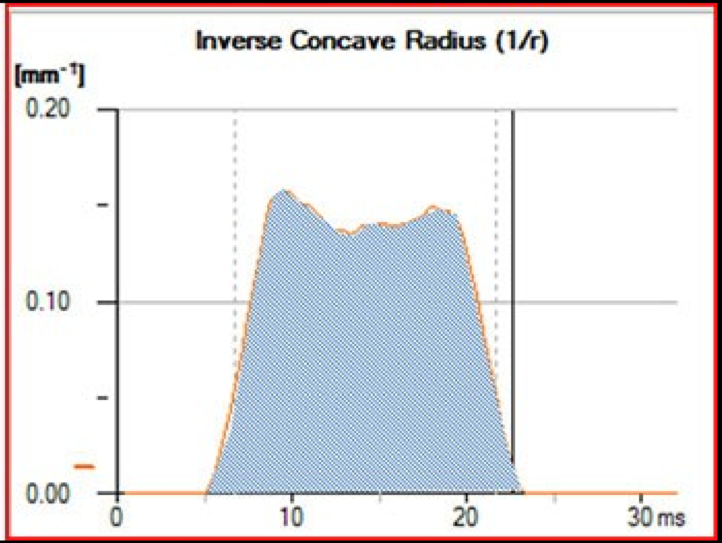
Deformation response to an air-pulse includes:
corneal deformation and the globe being pushed into the socket

CORVIS ST – DCR – DA ratio 2 mm



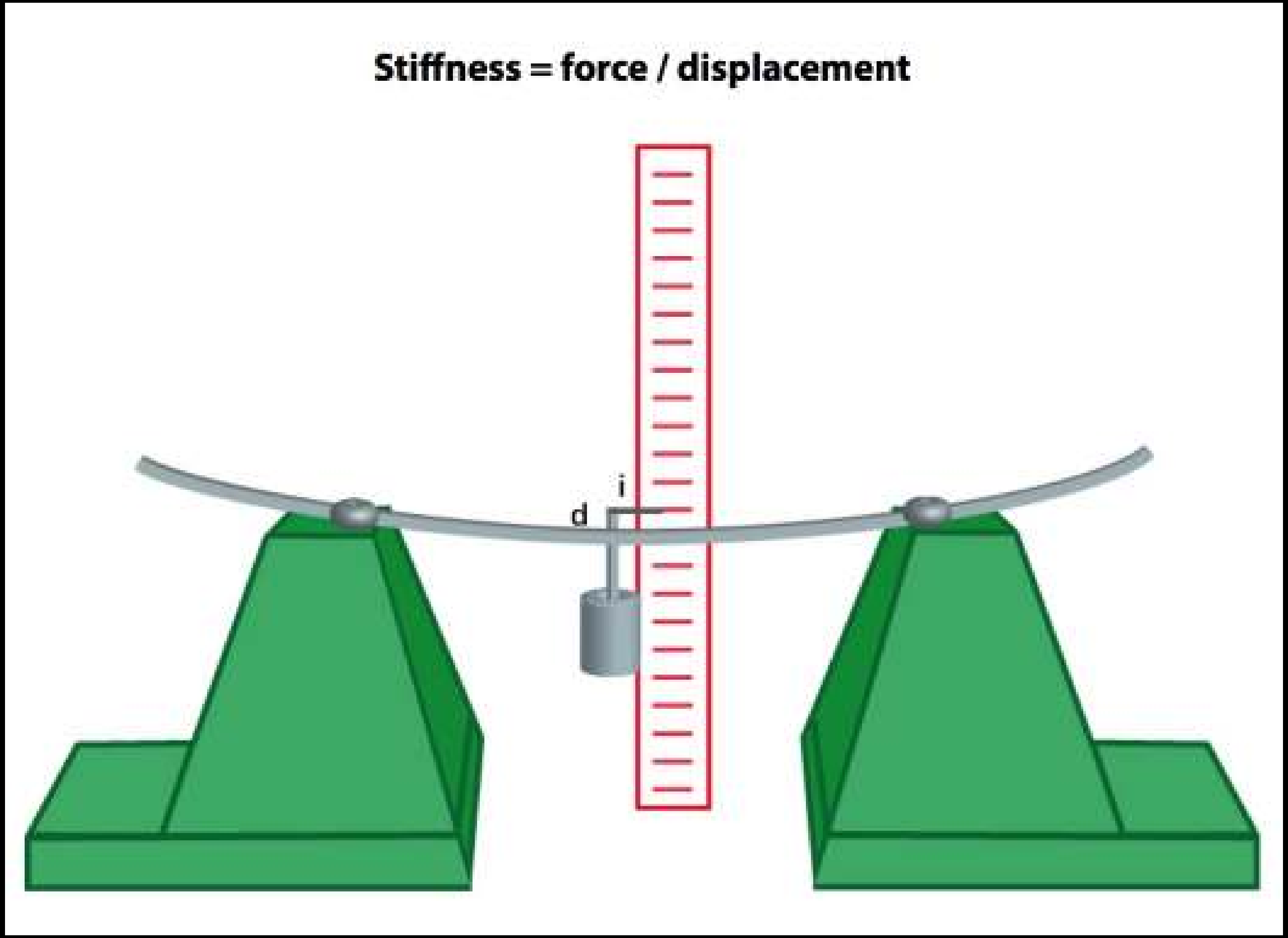
CORVIS ST – DCR - IR



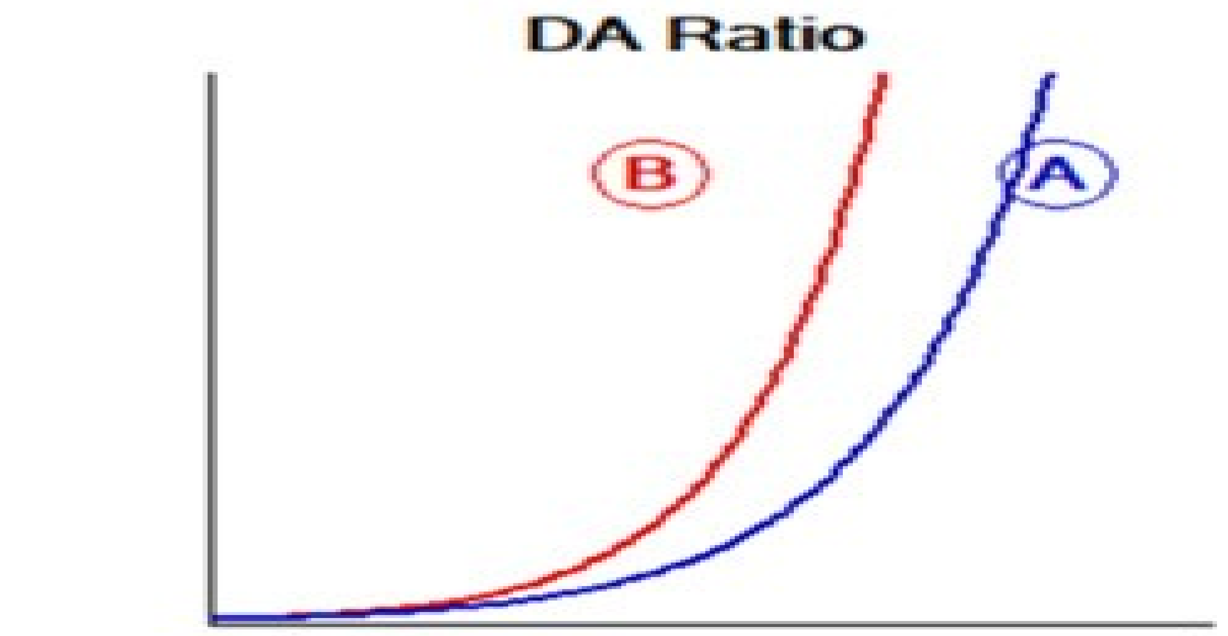


The central Radius of curvature is calculated. The inverse Radius (1 / R) is calculated and the area under this inverse Radius vs. time curve is determined. This area is called integrated Radius and is a very good parameter to quantify the effect of corneal cross-linking. If this parameter gets smaller it indicates a stiffening of the cornea.

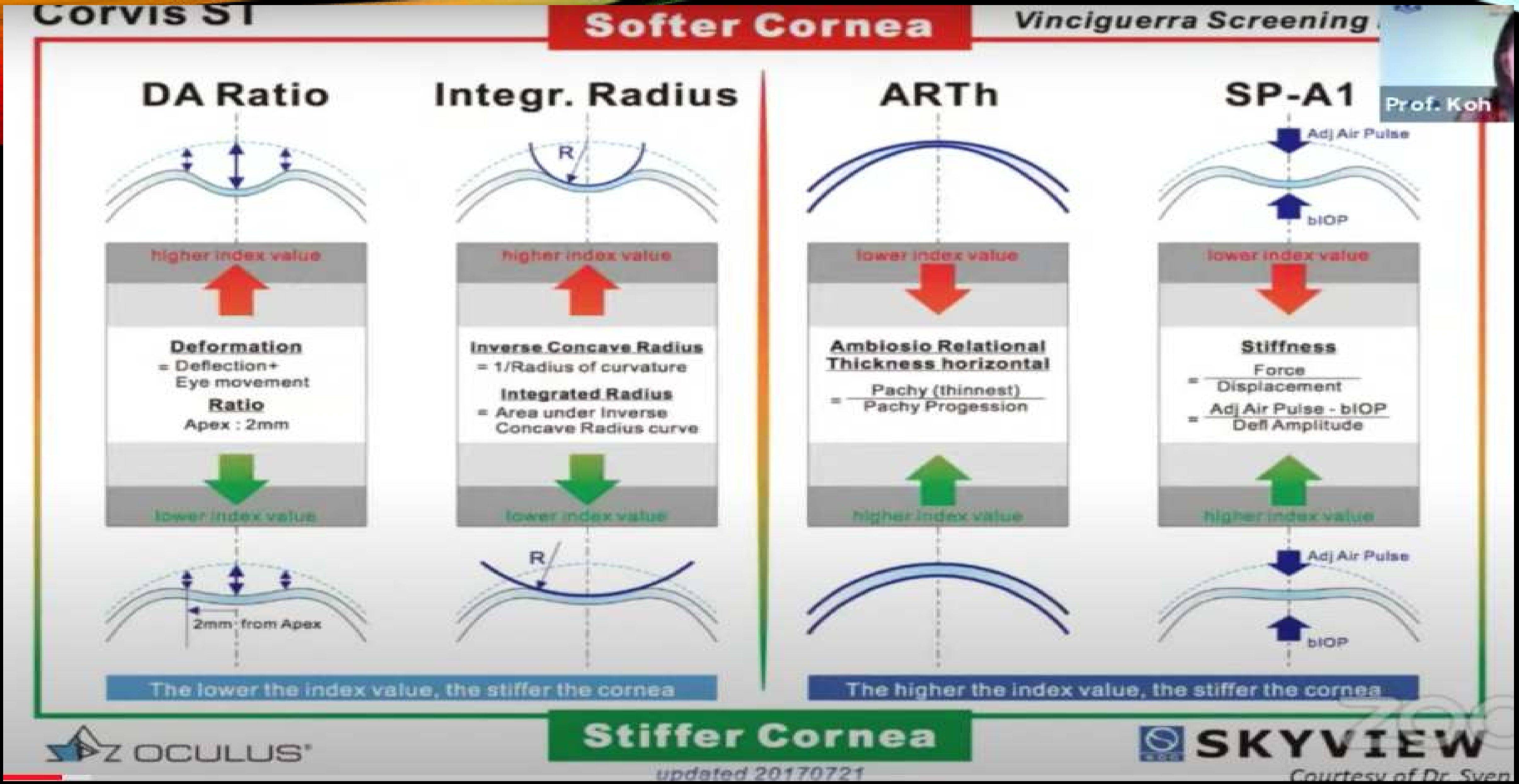
CORVIS ST – stiffness parameter (SP)



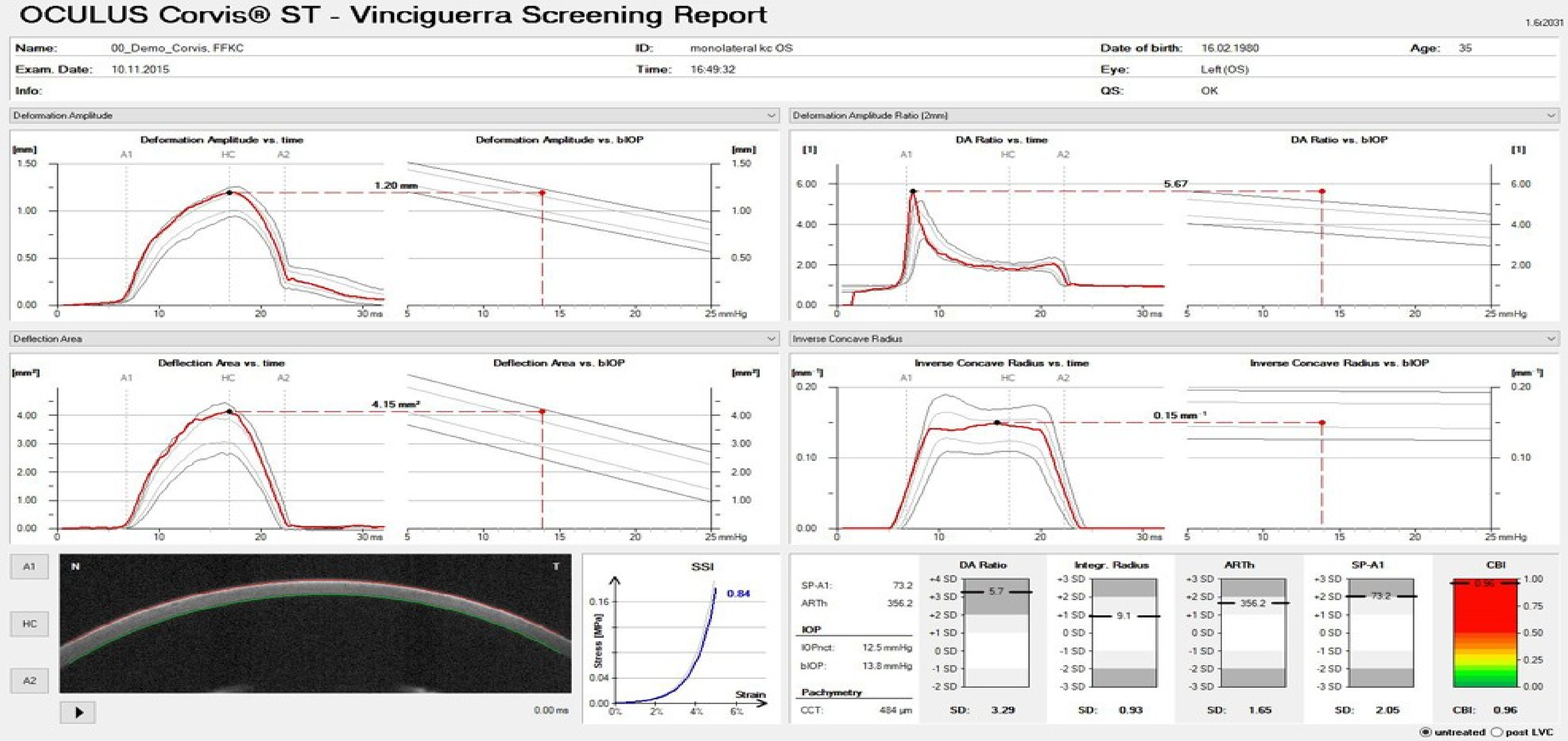
CORVIS ST – stress strain curve SST

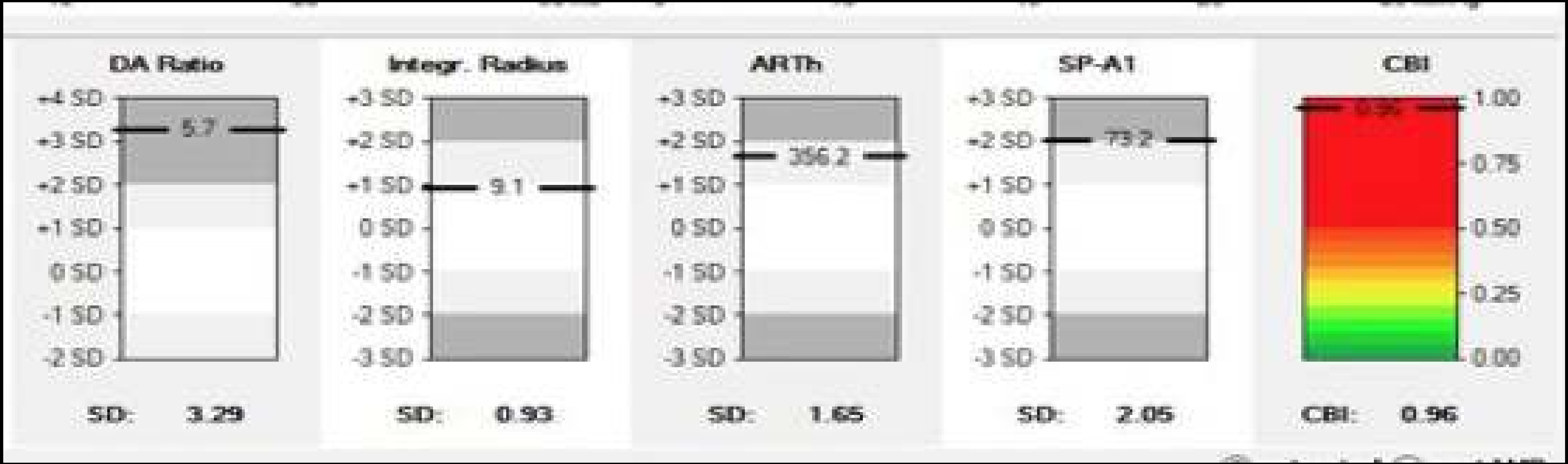


Value:	0.8	0.9
SD:	2.2	1.7
Diff. SD:	-0.5	
Change:	softer / not sign.	stiffer

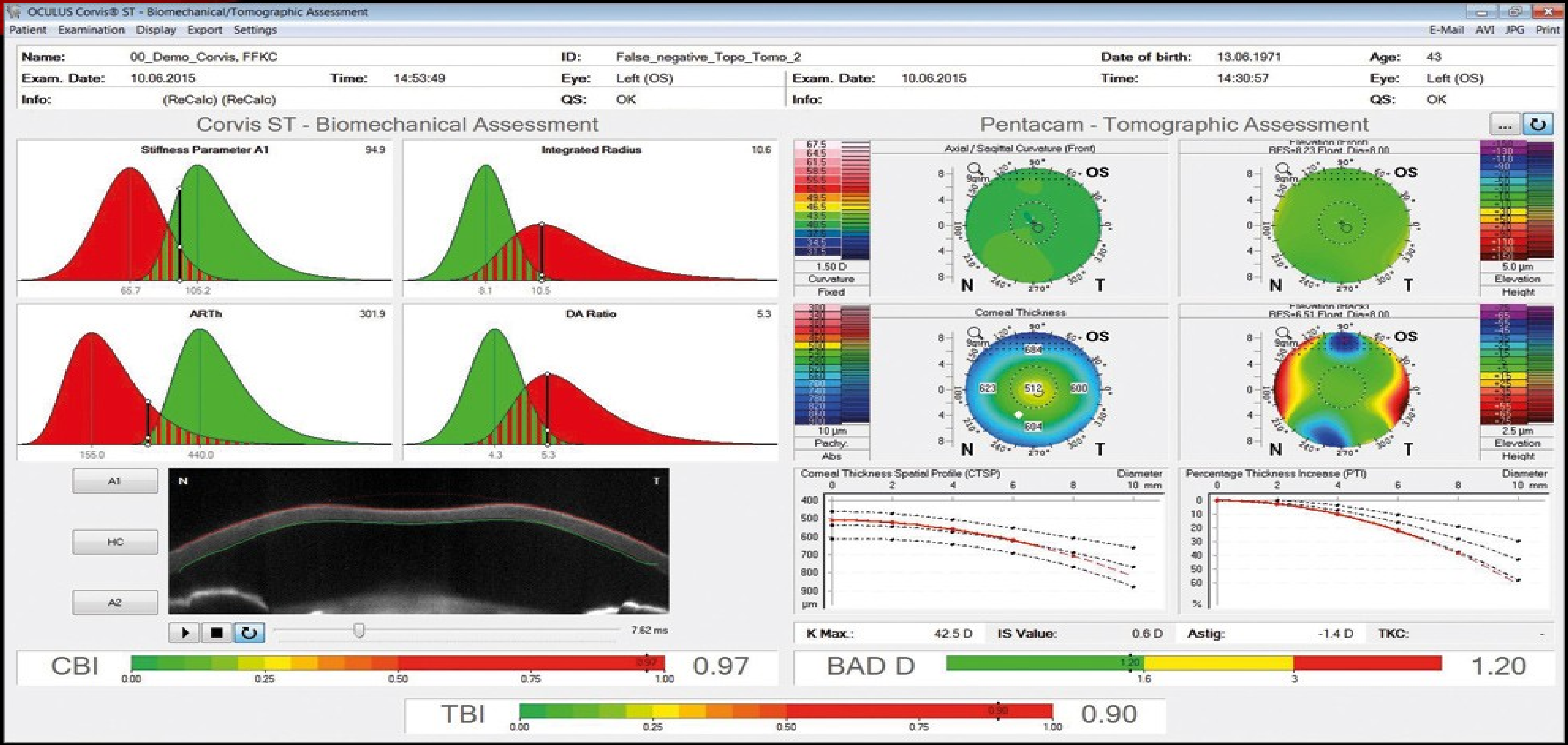

Corvis ST
Softer Cornea
Vinciguerra Screening
Prof. Koh
DA Ratio
Integr. Radius
ARTh
SP-A1
Adj Air Pulse
bIOP
higher index value
lower index value
Deformation
= Deflection+ Eye movement
Ratio
Apex : 2mm
Inverse Concave Radius
= 1/Radius of curvature
Integrated Radius
= Area under Inverse Concave Radius curve
Ambiosio Relational Thickness horizontal
= Pachy (thinnest) / Pachy Progession
Stiffness
= Force / Displacement
= Adj Air Pulse - bIOP / Defl Amplitude
2mm from Apex
R
The lower the index value, the stiffer the cornea
The higher the index value, the stiffer the cornea
Stiffer Cornea
OCULUS
SKYVIEW
updated 20170721
Courtesy of Dr. Sven

CORVIS ST – CBI

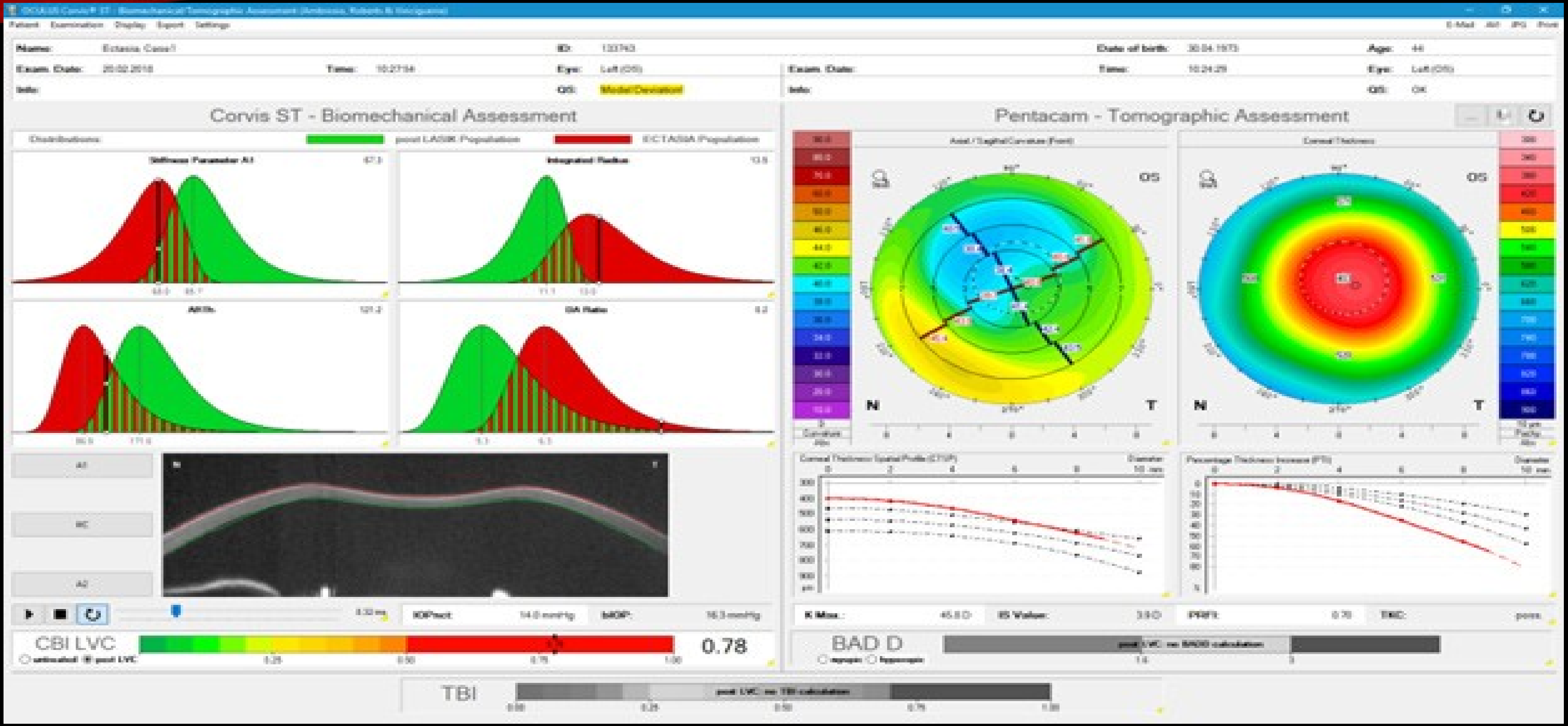



DA Ratio
+4 SD
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
5.7
SD: 3.29
Integr. Radius
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
9.1
SD: 0.93
ARTh
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
356.2
SD: 1.65
SP-A1
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
73.2
SD: 2.05
CBI
1.00
0.75
0.50
0.25
0.00
CBI: 0.96

CORVIS ST – TBI



CORVIS ST – CBI-LVC



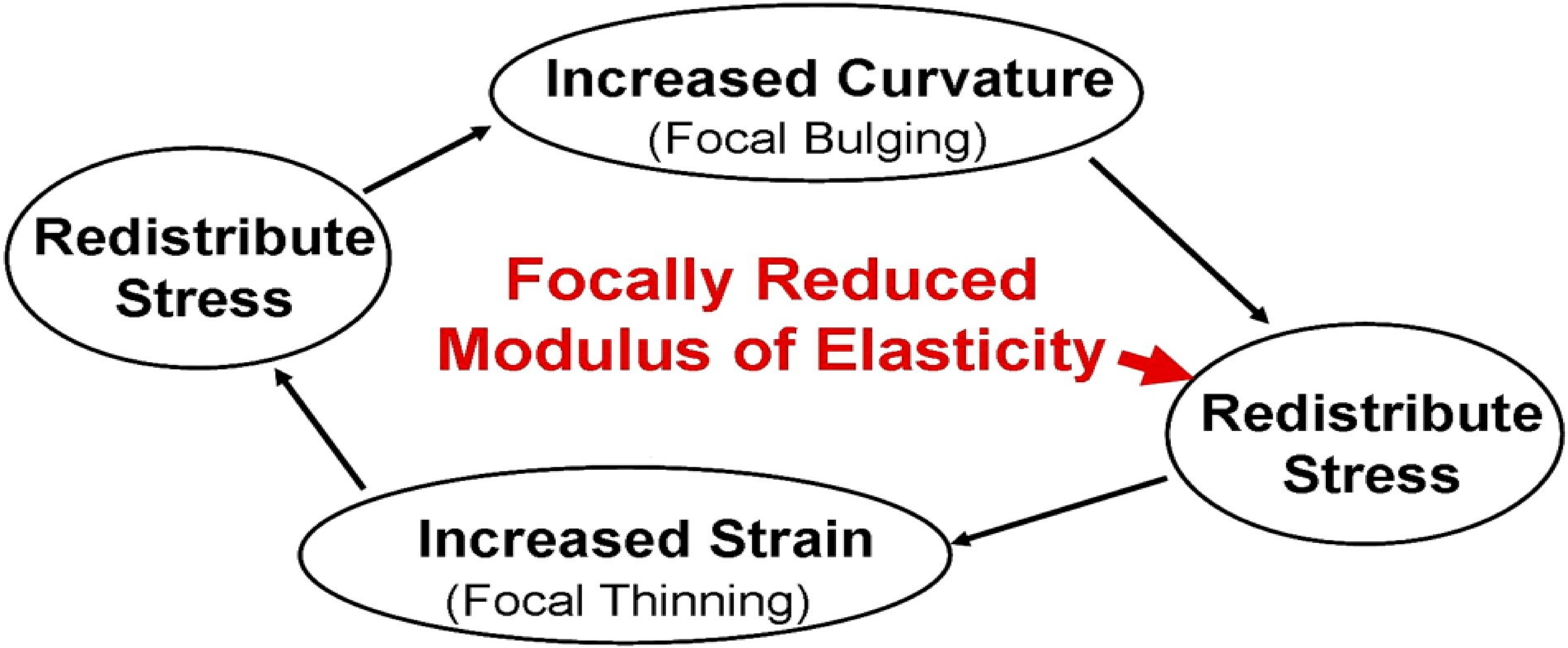
Clinical application

DIAGNOSIS
&
DETECTION

The current concept is that the pathophysiology of ectatic diseases is associated with

<u>Primary *biomechanical* abnormality</u>

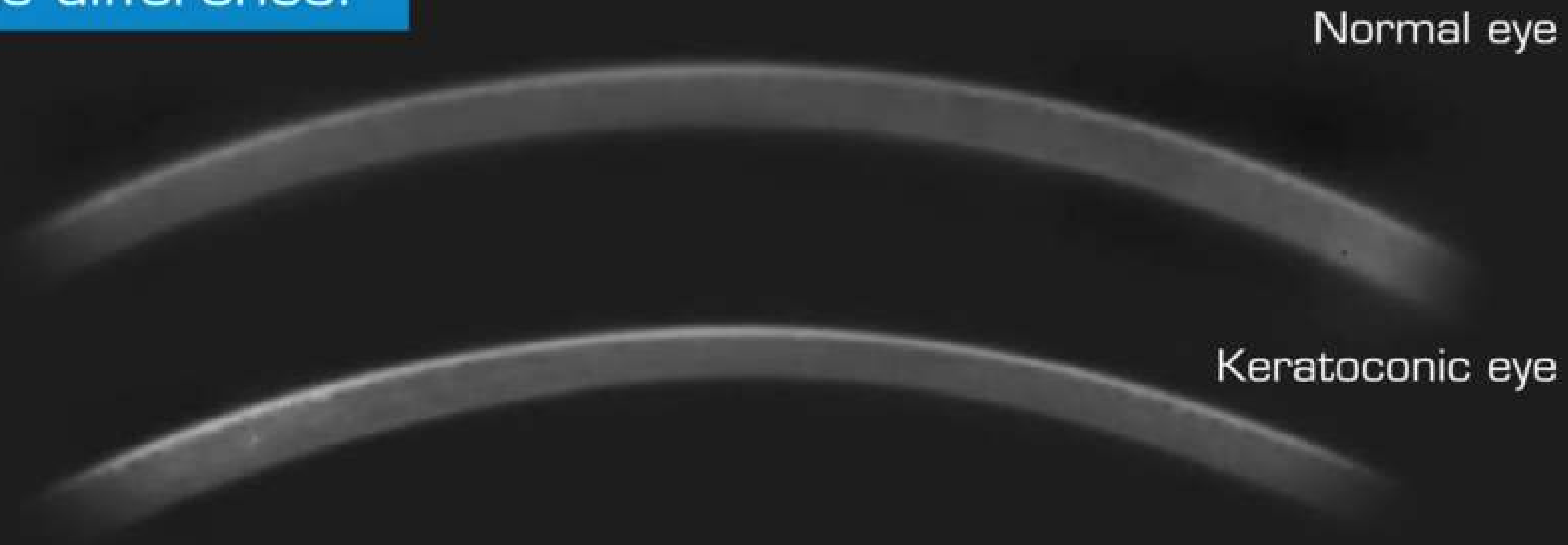
Biomechanical Cycle of Decompensation in Ectasia



UNDERSTANDING THE **CORNEA'S BIOMECHANICAL BEHAVIOR** IS RELEVANT FOR THE DETECTION OF **SUBCLINICAL KC** AS WELL AS FOR DETECTION OF **ECTASIA PROGRESSION**, WHILE CHANGES IN TOPOGRAPHY ARE STILL INSUFFICIENT TO PROVIDE CONCLUSIVE EVIDENCE

Normal vs. Keratoconus

See the difference!



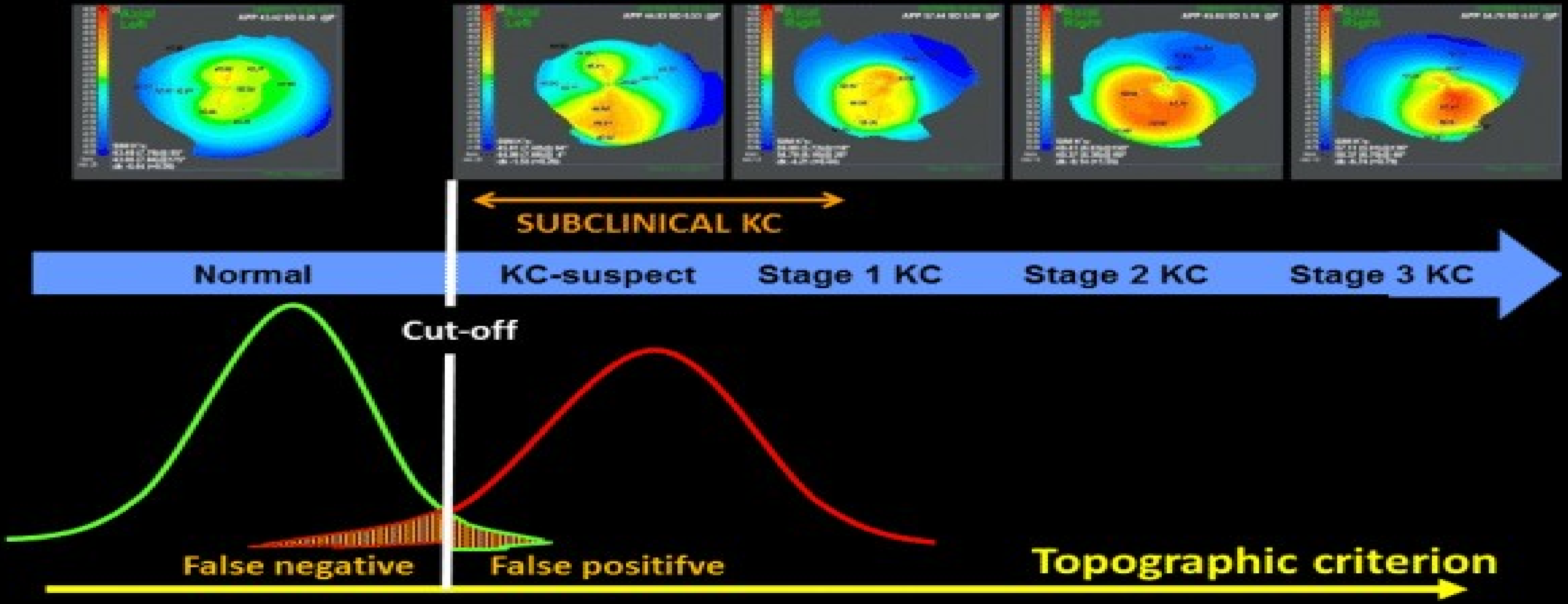
Provided by Renato Ambrósio Jr

OCULUS®

No criterion = 100% sensitive and specific

"Normal" can be "abnormal", but just below the limit of detection

"Abormal" can be "normal", but just above the limit of detection



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DIFFERENT SCENARIOS CASE 1→_

ID:	57141		
Date of Birth:	12/16/1990	Eye:	Right
Exam Date:	12/01/2024	Time:	13:47:52
Exam Info:			

Cornea Front

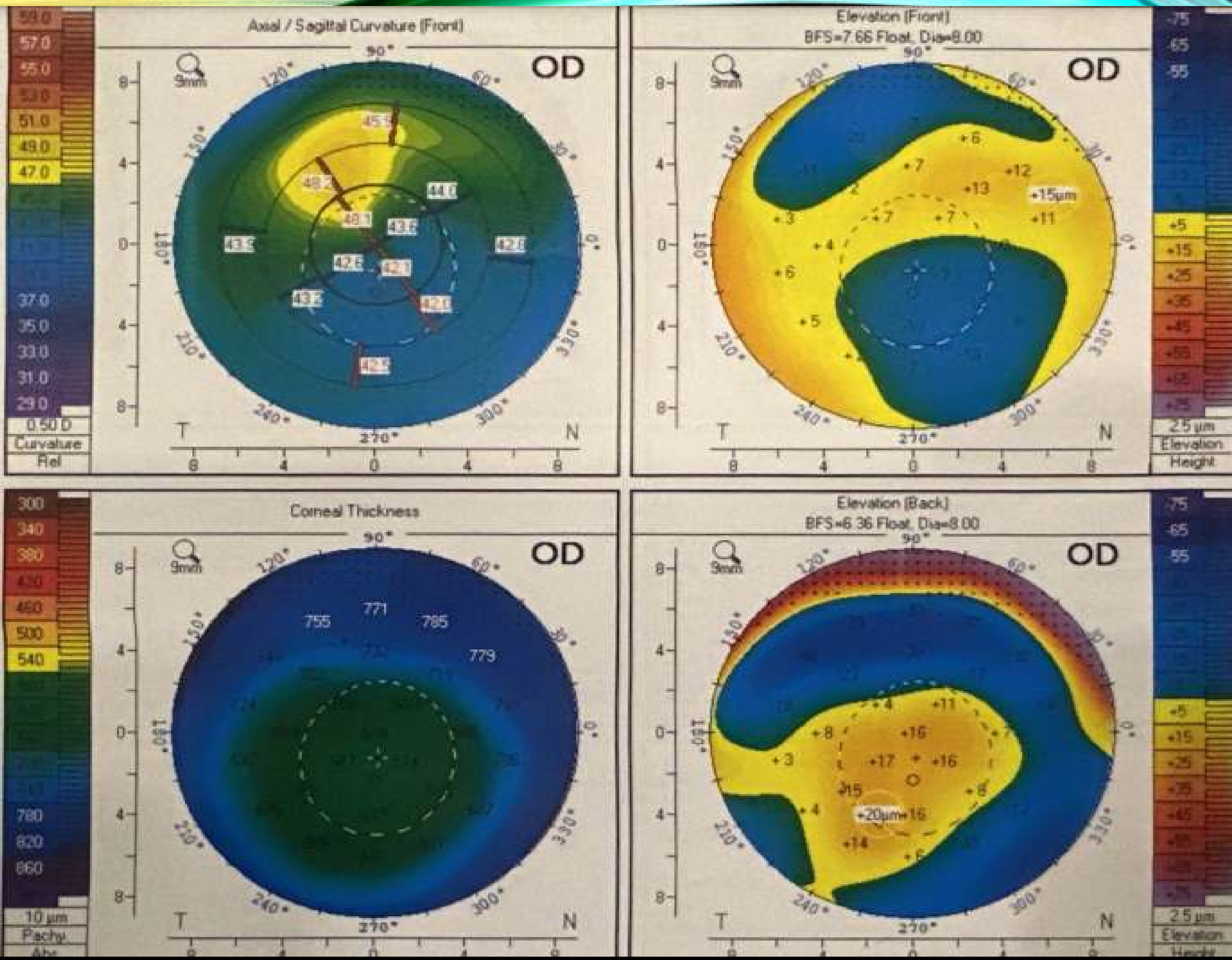
Rf:	7.84 mm	K1:	43.1 D
Rs:	7.52 mm	K2:	44.9 D
Rm:	7.68 mm	Km:	43.9 D
QS: OK	Axis (steep): 127.0°	Astig:	1.8 D
Q-val (8mm): -0.26	Rper: 7.86 mm	Rmin:	6.95 mm

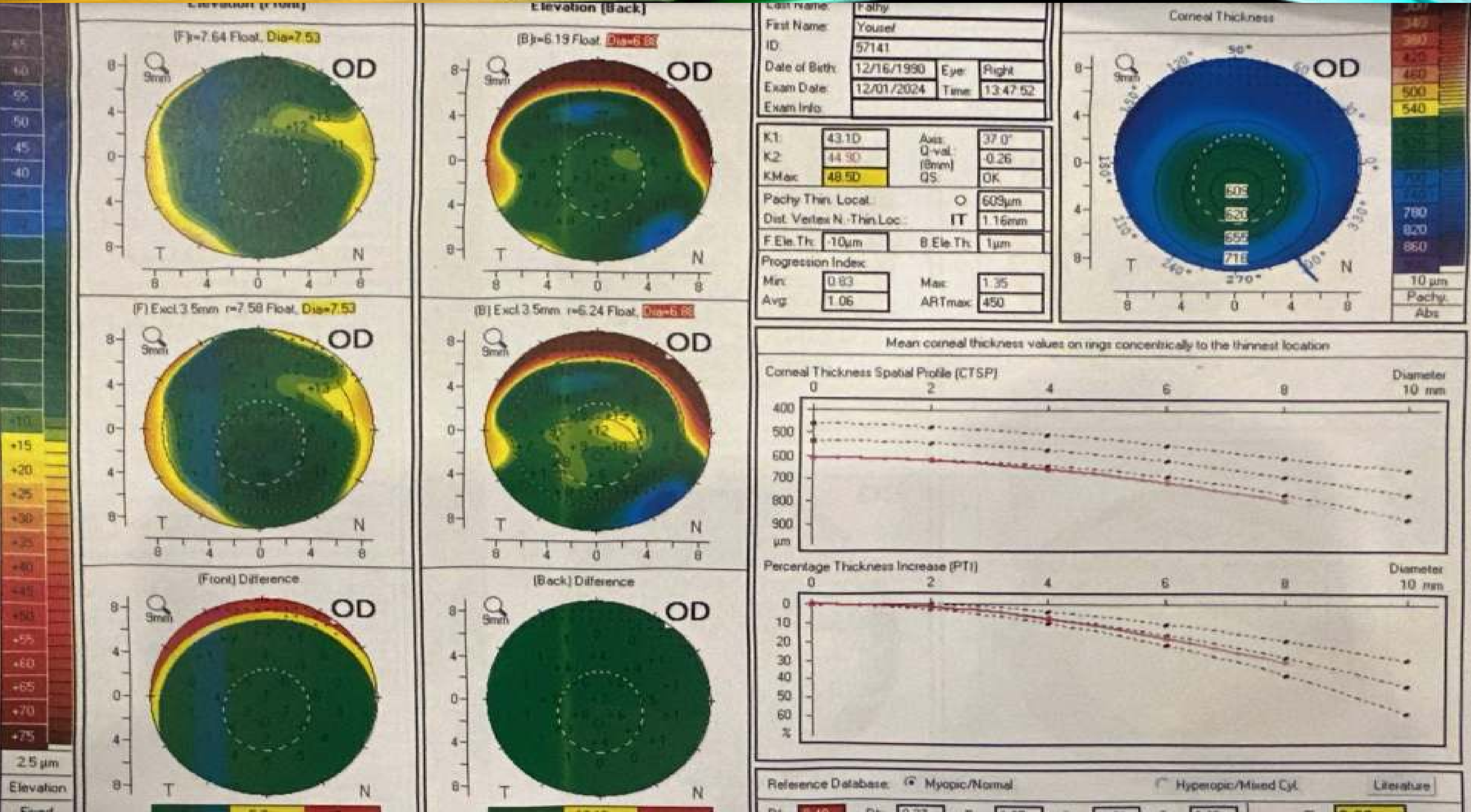
Cornea Back

Rf:	6.18 mm	K1:	-6.5 D
Rs:	5.87 mm	K2:	-6.8 D
Rm:	6.03 mm	Km:	-6.6 D
QS: OK	Axis (steep): 100.8°	Astig:	0.3 D
Q-val (8mm): -0.54	Rper: 6.50 mm	Rmin:	5.39 mm

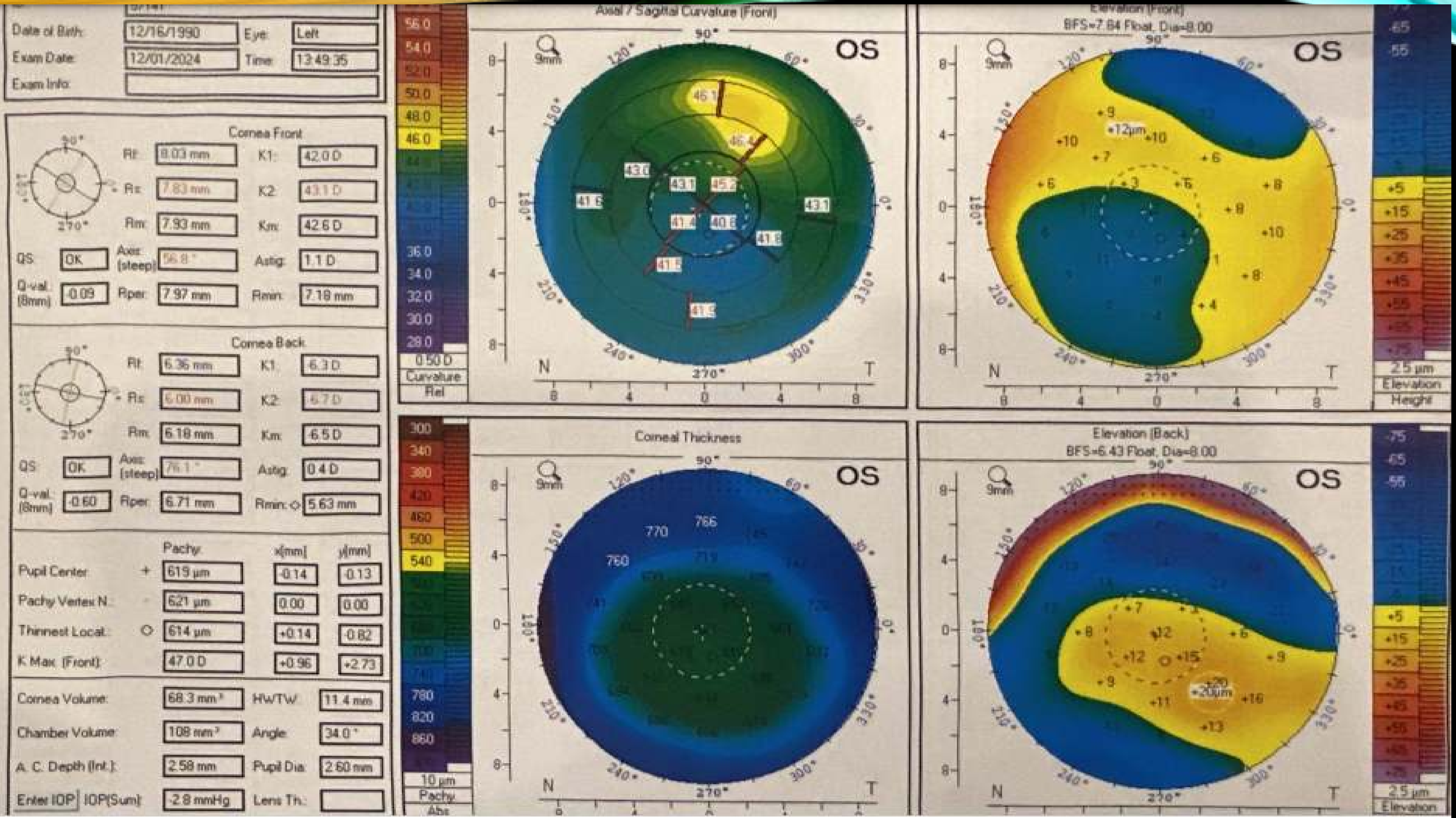
	Pachy:	x[mm]	y[mm]
Pupil Center: +	612 µm	+0.07	-0.65
Pachy Vertex N.:	624 µm	0.00	0.00
Thinnest Locat.: ○	609 µm	0.00	-1.16
K Max. (Front):	48.5 D	-0.82	+1.78

Cornea Volume:	68.8 mm³	HWTW:	11.2 mm
Chamber Volume:	110 mm³	Angle:	32.5°
A. C. Depth (Int.):	2.59 mm	Pupil Dia:	3.57 mm
Enter IOP | IOP(Sum):	-3.0 mmHg	Lens Th.:	

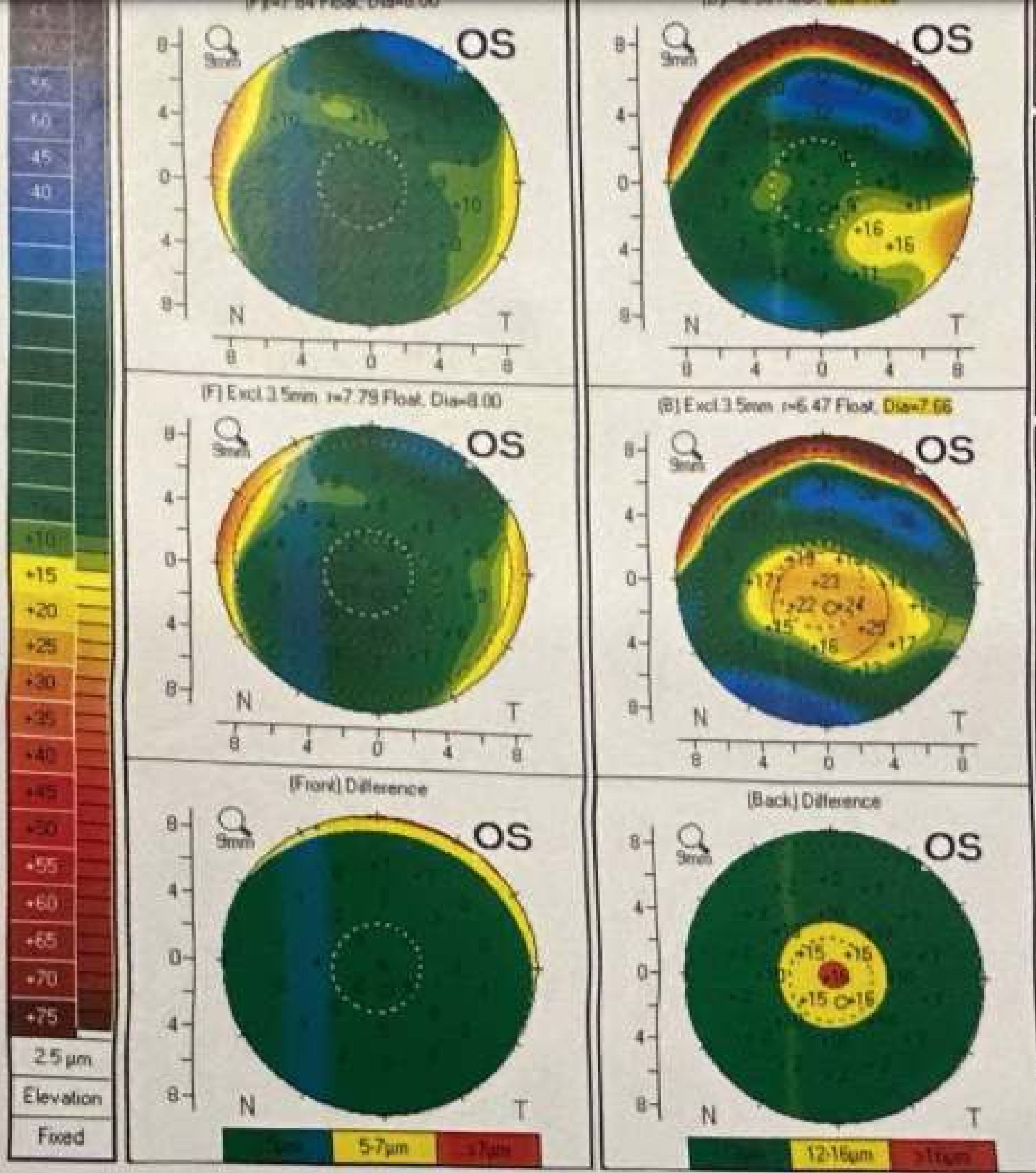




Elevation (Front)
Elevation (Back)
(F)r=7.64 Float, Dia=7.53
(B)r=6.19 Float
OD
(F) Excl.3.5mm r=7.58 Float, Dia=7.53
(B) Excl.3.5mm r=6.24 Float
(Front) Difference
(Back) Difference
9mm
T
N
2.5 µm
Elevation
Last Name: Fathy
First Name: Yousef
ID: 57141
Date of Birth: 12/16/1990
Eye: Right
Exam Date: 12/01/2024
Time: 13:47:52
Exam Info:
K1: 43.1D
K2: 44.9D
KMax: 48.5D
Axis: 37.0°
Q-val. (8mm): -0.26
QS: OK
Pachy Thin. Local.: 609µm
Dist. Vertex N.-Thin.Loc.: 1.16mm
F.Ele.Th: 10µm
B.Ele.Th: 1µm
Progression Index
Min: 0.83
Max: 1.35
Avg: 1.06
ARTmax: 450
Corneal Thickness
10 µm
Pachy
Abs
Mean corneal thickness values on rings concentrically to the thinnest location
Corneal Thickness Spatial Profile (CTSP)
Diameter 10 mm
µm
Percentage Thickness Increase (PTI)
%
Reference Database:
Myopic/Normal
Hyperopic/Mixed Cyl.
Literature

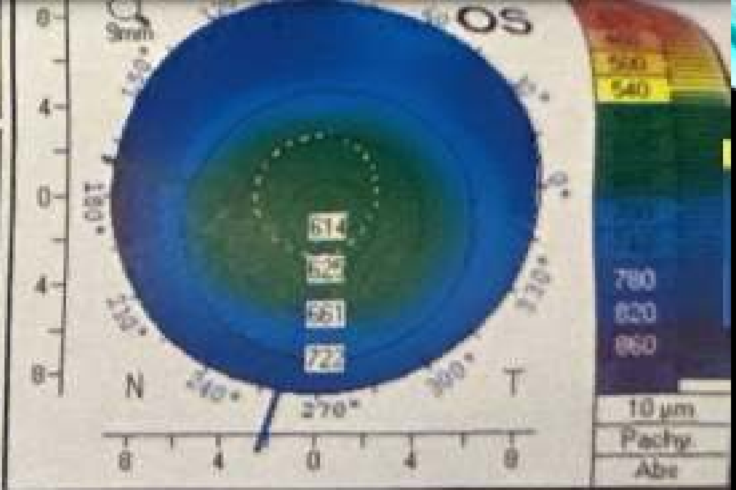


Date of Birth: 12/16/1990
Eye: Left
Exam Date: 12/01/2024
Time: 13:49:35
Exam Info:
Cornea Front
Rf: 8.03 mm
K1: 42.0 D
Rs: 7.83 mm
K2: 43.1 D
Rm: 7.93 mm
Km: 42.6 D
QS: OK
Axis (steep): 56.8°
Astig: 1.1 D
Q-val. (8mm): -0.09
Rper: 7.97 mm
Rmin: 7.18 mm
Cornea Back
Rf: 6.36 mm
K1: -6.3 D
Rs: 6.00 mm
K2: -6.7 D
Rm: 6.18 mm
Km: -6.5 D
QS: OK
Axis (steep): 76.1°
Astig: 0.4 D
Q-val. (8mm): -0.60
Rper: 6.71 mm
Rmin: 5.63 mm
Pachy: x[mm] y[mm]
Pupil Center: + 619 µm -0.14 -0.13
Pachy Vertex N: 621 µm 0.00 0.00
Thinnest Locat: 614 µm +0.14 -0.82
K Max (Front): 47.0 D +0.96 +2.73
Cornea Volume: 68.3 mm³
HWTW: 11.4 mm
Chamber Volume: 108 mm³
Angle: 34.0°
A. C. Depth (Int.): 2.58 mm
Pupil Dia: 2.60 mm
Enter IOP
IOP(Sum): 2.8 mmHg
Lens Th.:
Axial / Sagittal Curvature (Front)
OS
0.50 D
Curvature
Rel
Elevation (Front)
BFS=7.84 Float, Dia=8.00
OS
+12µm
2.5 µm
Elevation
Height
Corneal Thickness
OS
10 µm
Pachy
Abs
Elevation (Back)
BFS=6.43 Float, Dia=8.00
OS
+20µm
2.5 µm
Elevation
N
T

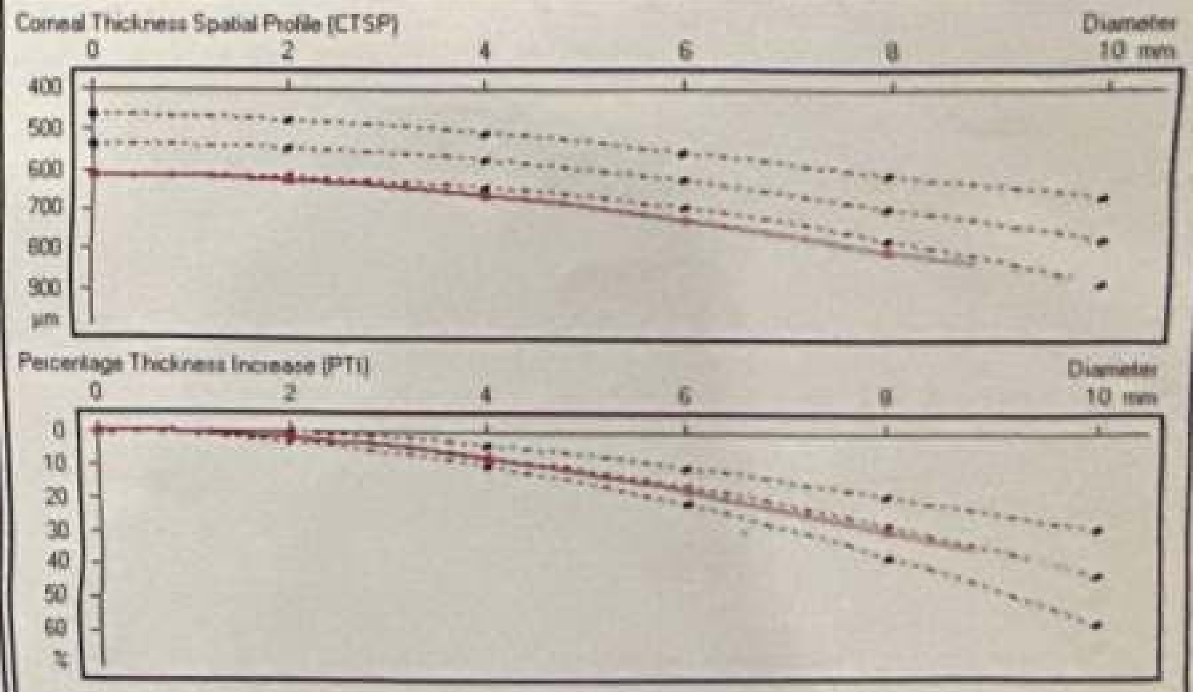


Date of Birth:	12/16/1990	Eye:	Left
Exam Date:	12/01/2024	Time:	13:49:35
Exam Info:			

K1:	42.0D	Axis:	146.8°
K2:	43.1D	Q-val. (8mm):	-0.09
KMax:	47.0D	QS:	OK
Pachy Thin. Locat.:			614µm
Dist. Vertex N.-Thin.Loc.:			0.83mm
F.Ele.Th:	-8µm	B.Ele.Th:	7µm
Progression Index:			
Min:	0.82	Max:	1.35
Avg:	1.07	ARTmax:	455

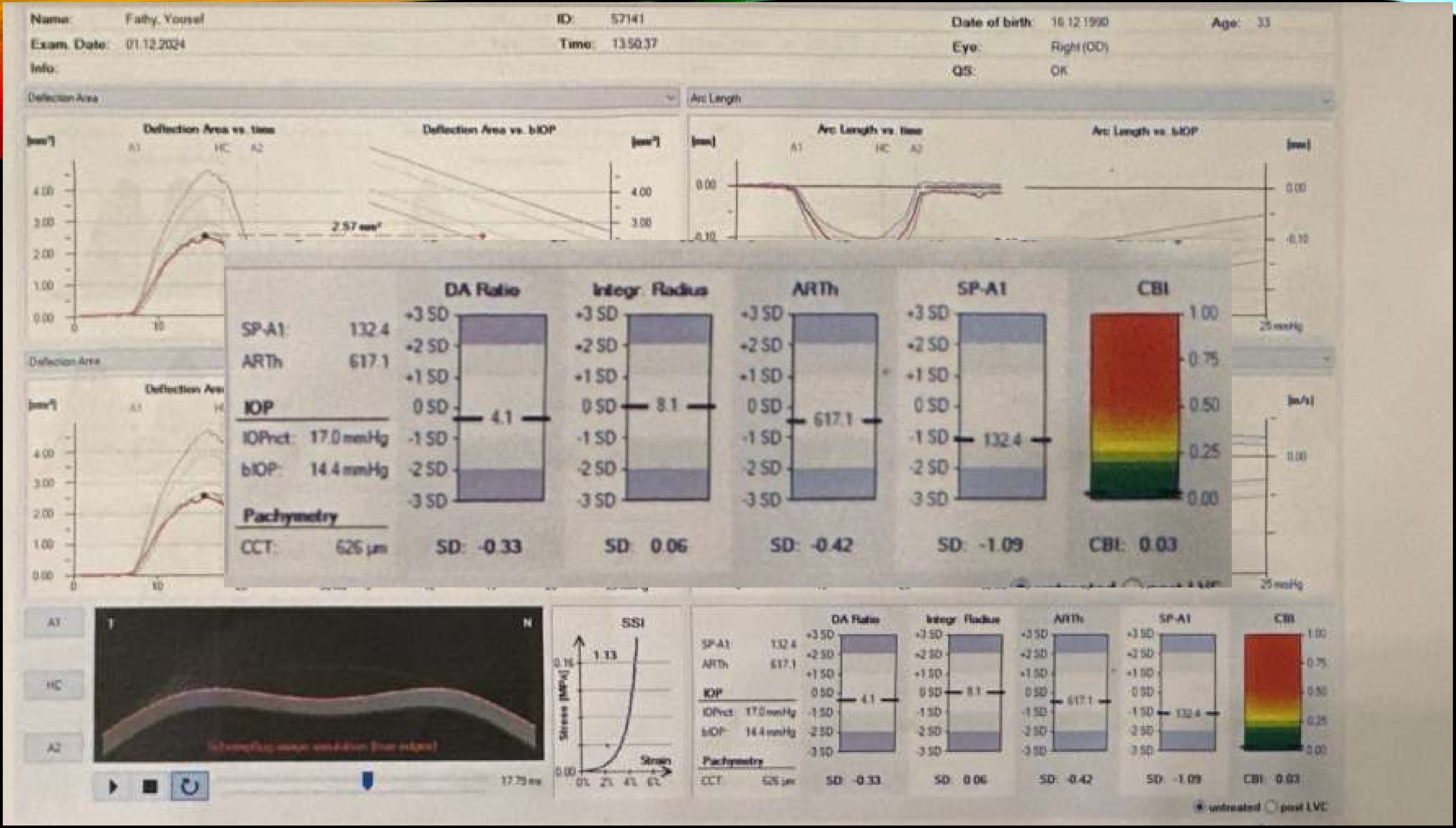


Mean corneal thickness values on rings concentrically to the thinnest location



Reference Database: Myopic/Normal Hyperopic/Mixed Cyl. Literature

Df:	Db:	Dp:	Dt:	Da:	D:
3.47	2.63	1.09	1.91	0.30	2.83


Name: Fathy, Yousef
ID: 57141
Date of birth: 16.12.1990
Age: 33
Exam. Date: 01.12.2024
Time: 13:50:37
Eye: Right (OD)
Info:
QS: OK
Deflection Area
Arc Length
Deflection Area vs. time
Deflection Area vs. bIOP
Arc Length vs. time
Arc Length vs. bIOP
2.57 mm²
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
SP-A1: 132.4
ARTh: 617.1
IOP
IOPnct: 17.0 mmHg
bIOP: 14.4 mmHg
Pachymetry
CCT: 626 µm
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
4.1
8.1
617.1
132.4
1.00
0.75
0.50
0.25
0.00
SD: -0.33
SD: 0.06
SD: -0.42
SD: -1.09
CBI: 0.03
A1
HC
A2
T
N
SSI
1.13
Stress [MPa]
Strain
untreated
post LVC

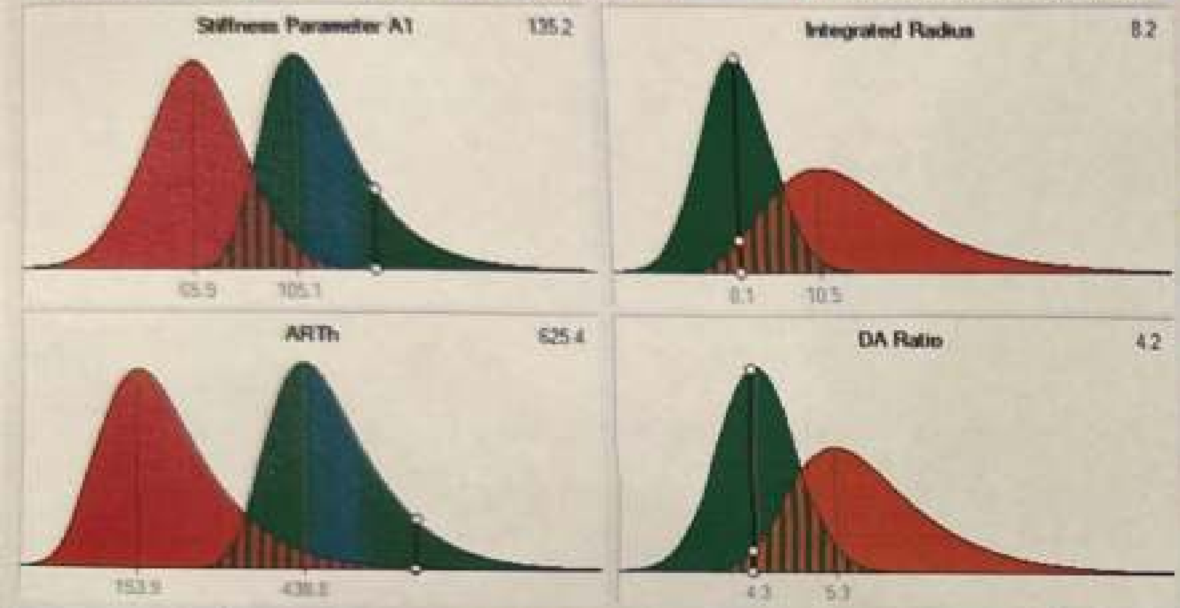
Corvis ST - Biomechanical Assessment
Pentacam - Tomographic Assessment
Distributions
NORMAL Population
KERATOCONUS Population
Stiffness Parameter A1
132.4
Integrated Radius
8.1
ARTh
617.1
DA Ratio
4.1
Axial / Sagittal Curvature (Front)
Corneal Thickness
OD
CBI
untreated
post LVC
0.25
0.50
0.75
1.00
0.03
BAD D
myopic
hyperopic
1.6
3
2.29
TBI
0.00
0.25
0.50
0.75
1.00
0.30
Corneal Thickness Spatial Profile (CTSP)
Percentage Thickness Increase (PTI)
Diameter
10 mm
17.79 ms
IOPnct:
17.0 mmHg
bIOP:
14.4 mmHg
K Max.:
48.5 D
IS Value:
-3.6 D
PRFI:
0.12
TKC:

Name:	Fathy, Yousef			**ID:**	57141	**Date of birth:** 16.12.1990	**Age:** 33
Exam. Date:	01.12.2024	**Time:**	13:50:51	**Eye:**	Left (OS)		
Info:				**QS:**	OK		

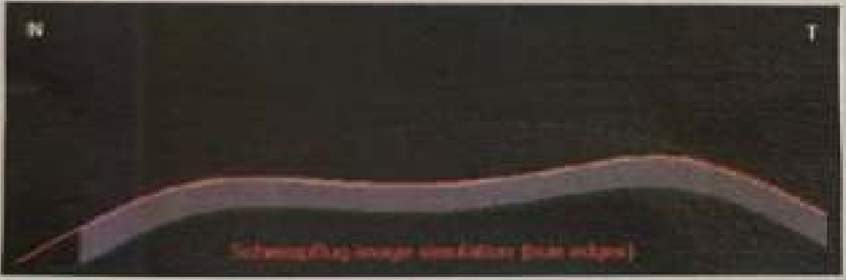
Exam. Date:	01.12.2024	**Time:**	13:49:35	**Eye:**	Left (OS)
Info:				**QS:**	OK

Corvis ST - Biomechanical Assessment

Distributions: NORMAL Population / KERATOCONUS Population



A1
HC
A2

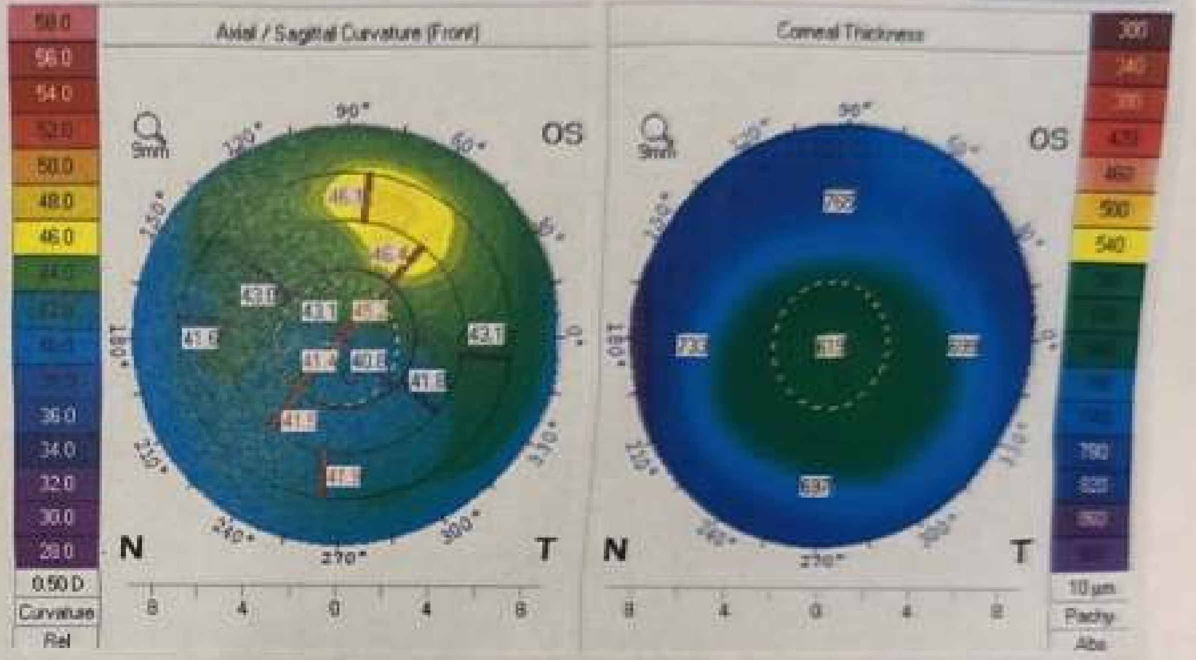


17.32 ms

IOPnct: 18.0 mmHg | bIOP: 15.5 mmHg

CBI 0.06 — ◉ untreated ○ post LVC — 0.25 0.50 0.75 1.00

Pentacam - Tomographic Assessment

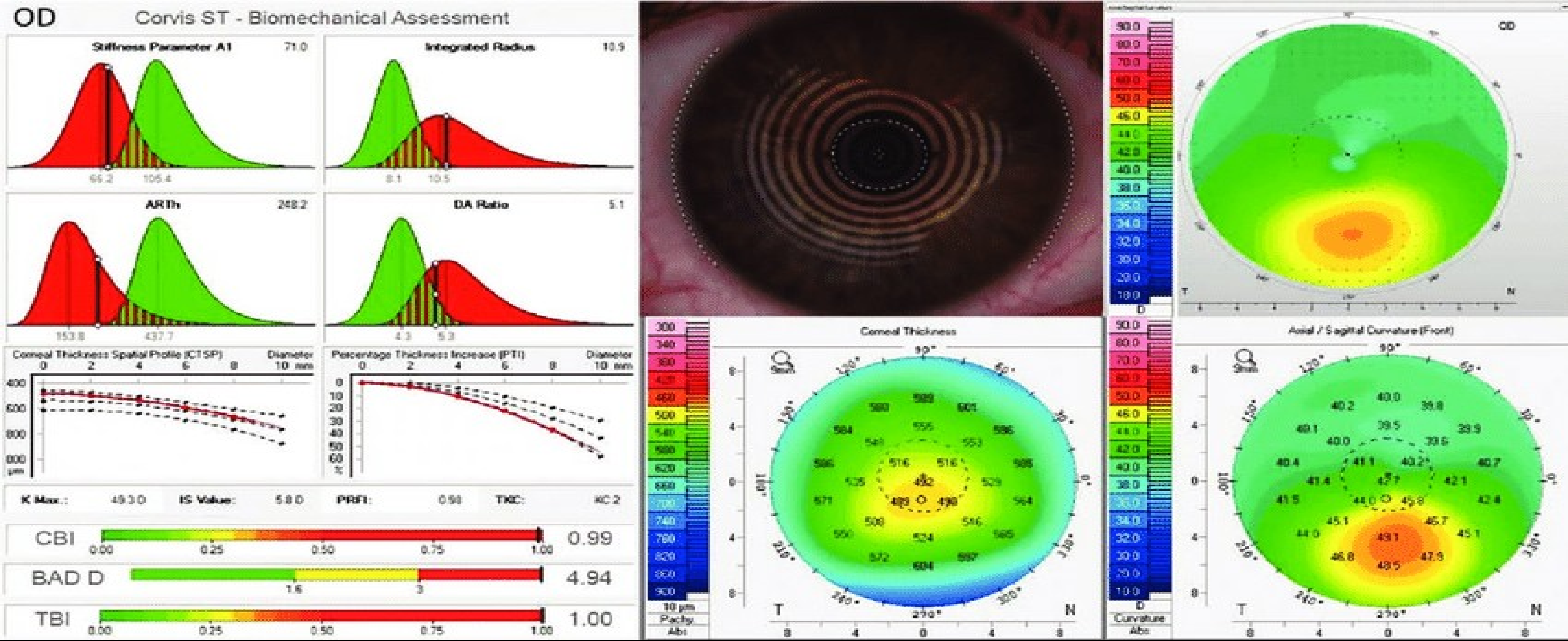


K Max.: 47.0 D | IS Value: -3.1 D | PRFI: 0.07 | TKC: -

BAD D 2.03 — ◉ myopic ○ hyperopic — 1.6 3

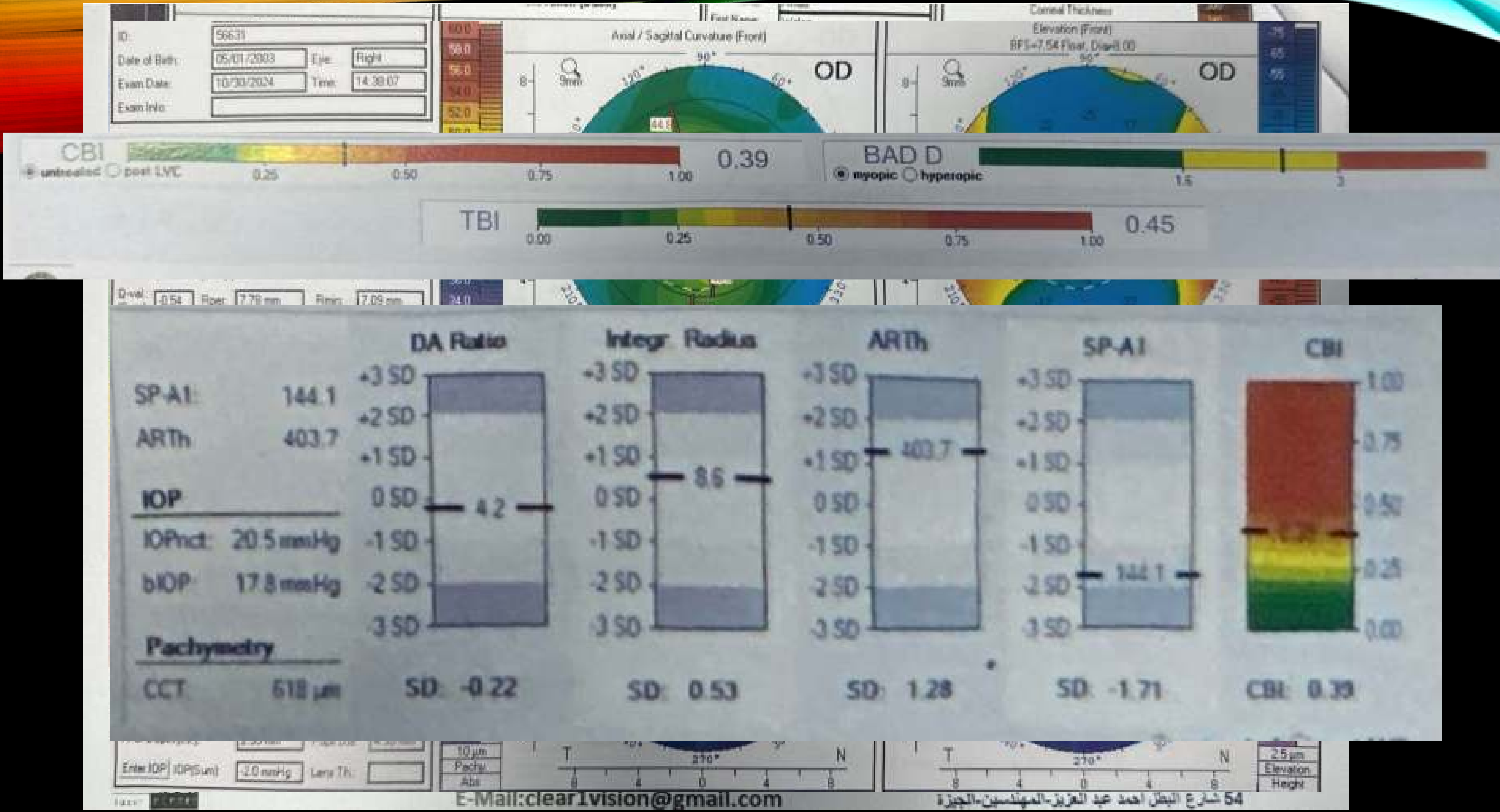
TBI 0.31 — 0.00 0.25 0.50 0.75 1.00

DIFFERENT SCENARIOS CASE 2 → ___



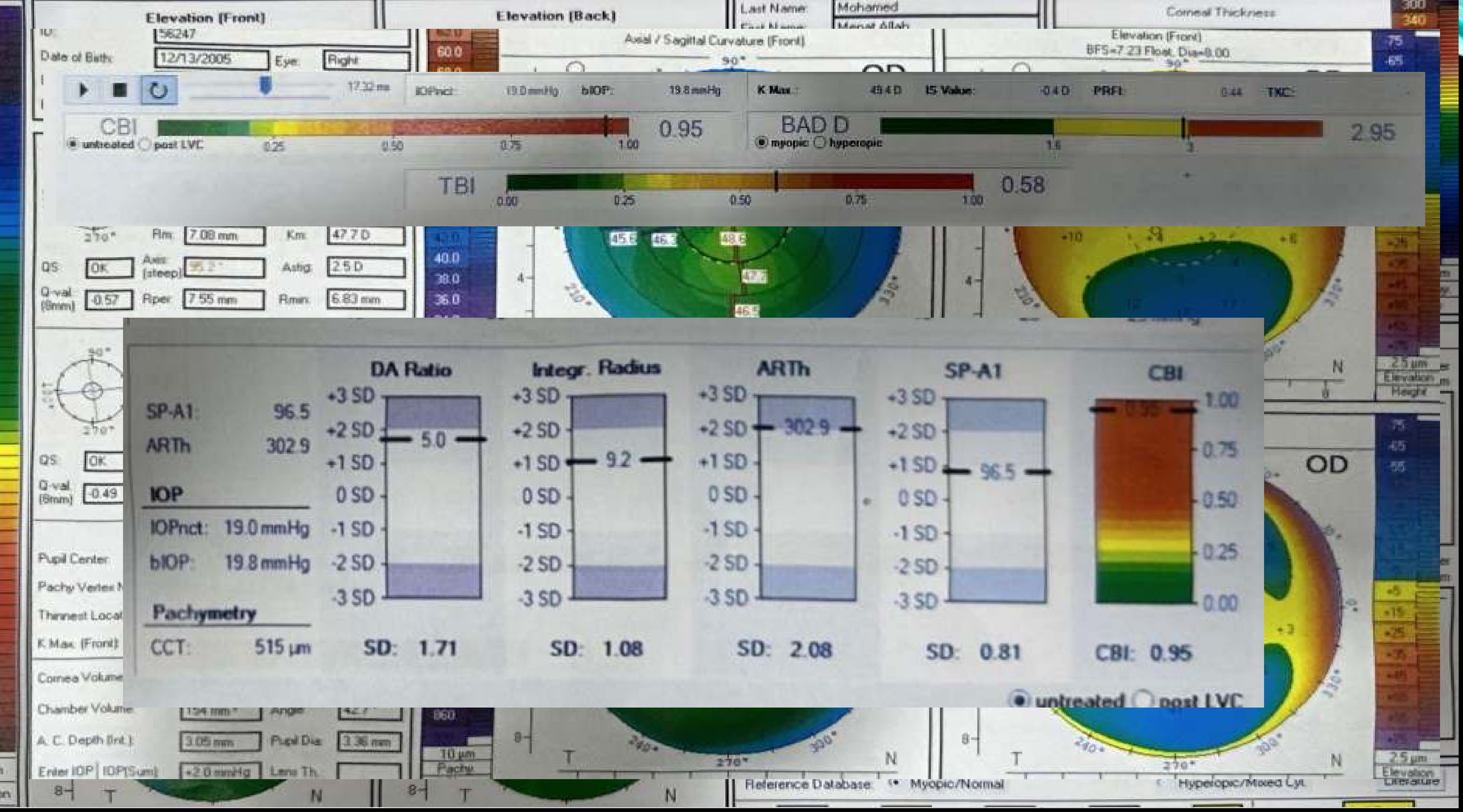
Composite with the TBI display (Corvis ST + Pentacam) and the Placido disk-based topography Advanced corneal tomographic and biomechanical analysis also revealed abnormal findings

DIFFERENT SCENARIOS CASE 3 → _



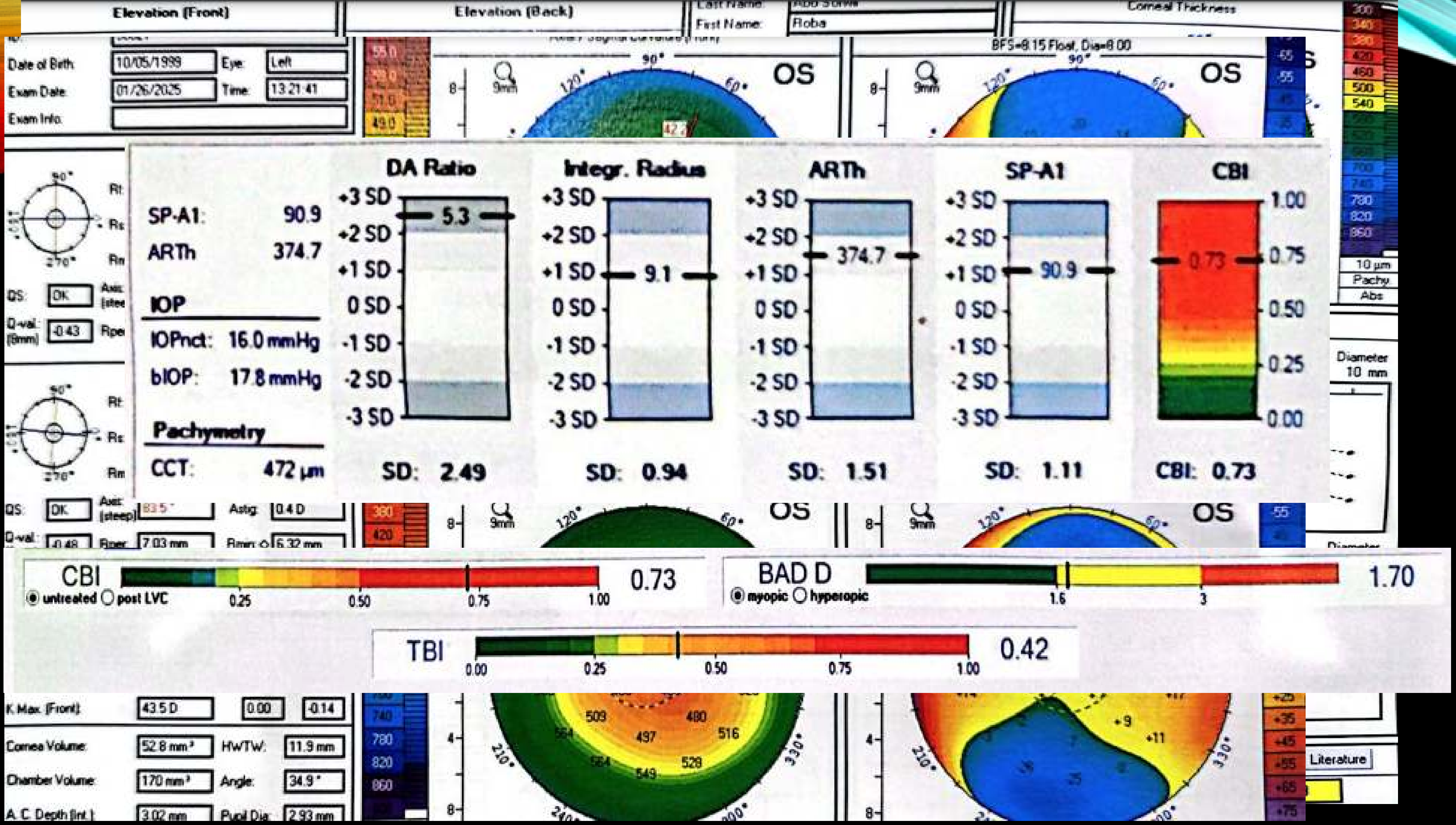
ID: 56631
Date of Birth: 05/01/2003
Eye: Right
Exam Date: 10/30/2024
Time: 14:38:07
Exam Info:
Axial / Sagittal Curvature (Front)
OD
Corneal Thickness
Elevation (Front)
OD
CBI
untreated
post LVC
0.25
0.50
0.75
1.00
0.39
BAD D
myopic
hyperopic
1.5
3
TBI
0.00
0.25
0.50
0.75
1.00
0.45
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
SP-A1: 144.1
ARTh: 403.7
IOP
IOPnct: 20.5 mmHg
bIOP: 17.8 mmHg
Pachymetry
CCT: 618 µm
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
4.2
8.6
403.7
144.1
1.00
0.75
0.50
0.25
0.00
SD: -0.22
SD: 0.53
SD: 1.28
SD: -1.71
CBI: 0.39
Enter IOP
IOP(Sum)
2.0 mmHg
Lens Th.
E-Mail:clear1vision@gmail.com
54 شارع البطل احمد عبد العزيز-المهندسين-الجيزة

DIFFERENT SCENARIOS CASE 4→__



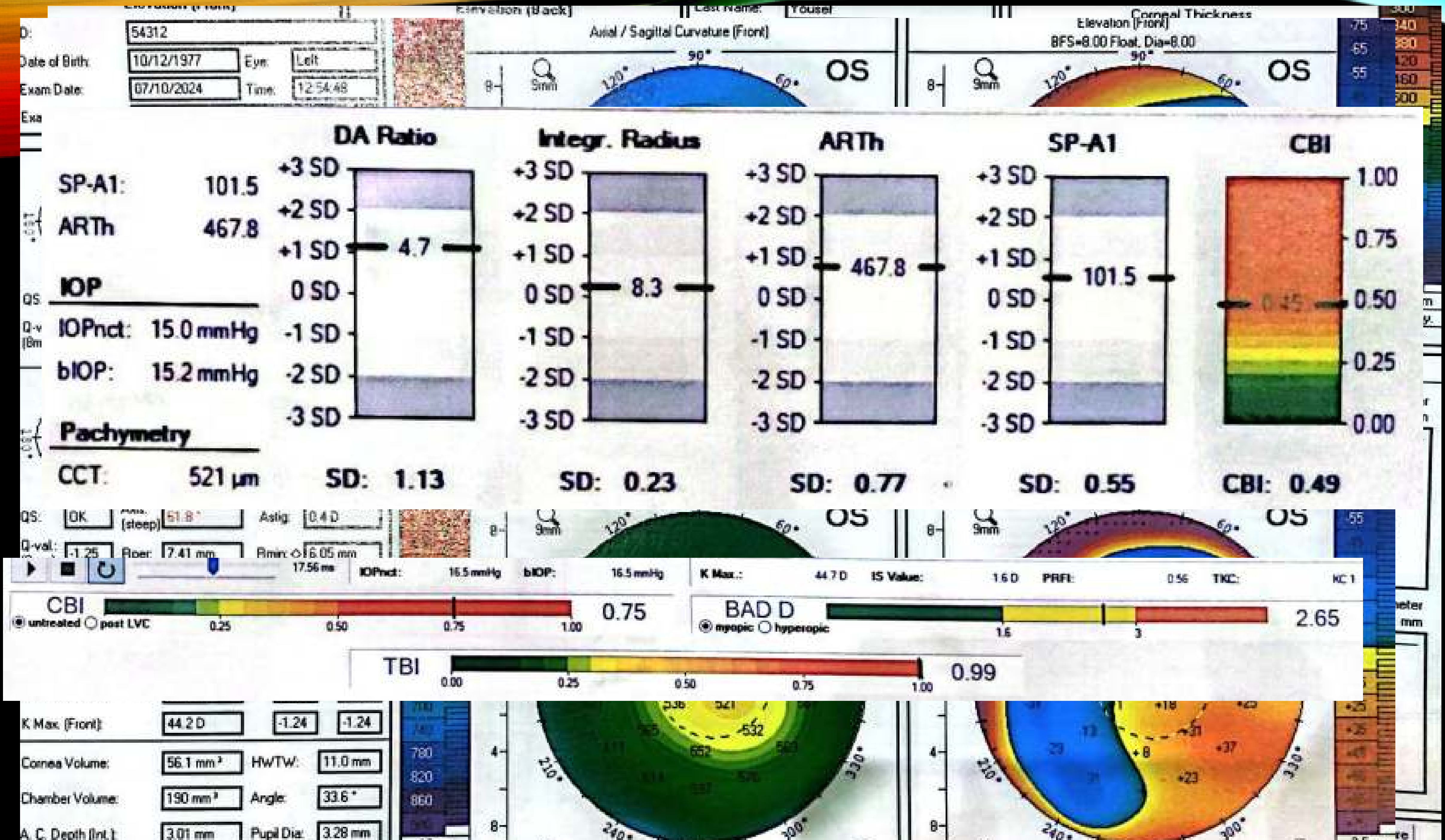
Elevation (Front)
Elevation (Back)
Last Name: Mohamed
Corneal Thickness
ID: 56247
Date of Birth: 12/13/2005
Eye: Right
Axial / Sagittal Curvature (Front)
Elevation (Front)
BFS=7.23 Float, Dia=8.00
17.32 ms
IOPnct: 19.0 mmHg
bIOP: 19.8 mmHg
K Max: 49.4 D
IS Value: -0.4 D
PRFI: 0.44
TKC:
CBI
unheated
post LVC
0.25
0.50
0.75
1.00
0.95
BAD D
myopic
hyperopic
1.6
3
2.95
TBI
0.00
0.25
0.50
0.75
1.00
0.58
Rm: 7.08 mm
Km: 47.7 D
QS: OK
Axis (steep):
Astig: 2.5 D
Q-val. (8mm): -0.57
Rper: 7.55 mm
Rmin: 6.83 mm
QS: OK
Q-val. (8mm): -0.49
SP-A1: 96.5
ARTh: 302.9
IOP
IOPnct: 19.0 mmHg
bIOP: 19.8 mmHg
Pachymetry
CCT: 515 µm
DA Ratio
5.0
SD: 1.71
Integr. Radius
9.2
SD: 1.08
ARTh
302.9
SD: 2.08
SP-A1
96.5
SD: 0.81
CBI
CBI: 0.95
+3 SD
+2 SD
+1 SD
0 SD
-1 SD
-2 SD
-3 SD
1.00
0.75
0.50
0.25
0.00
untreated
post LVC
OD
Pupil Center
Thinnest Locat
K Max (Front)
Cornea Volume
Chamber Volume
A. C. Depth (Int.): 3.05 mm
Pupil Dia: 3.36 mm
Enter IOP
IOP(Sum)
+2.0 mmHg
Lens Th.
Reference Database: Myopic/Normal
Hypelopic/Mixed Cyl.

DIFFERENT SCENARIOS CASE 5→________



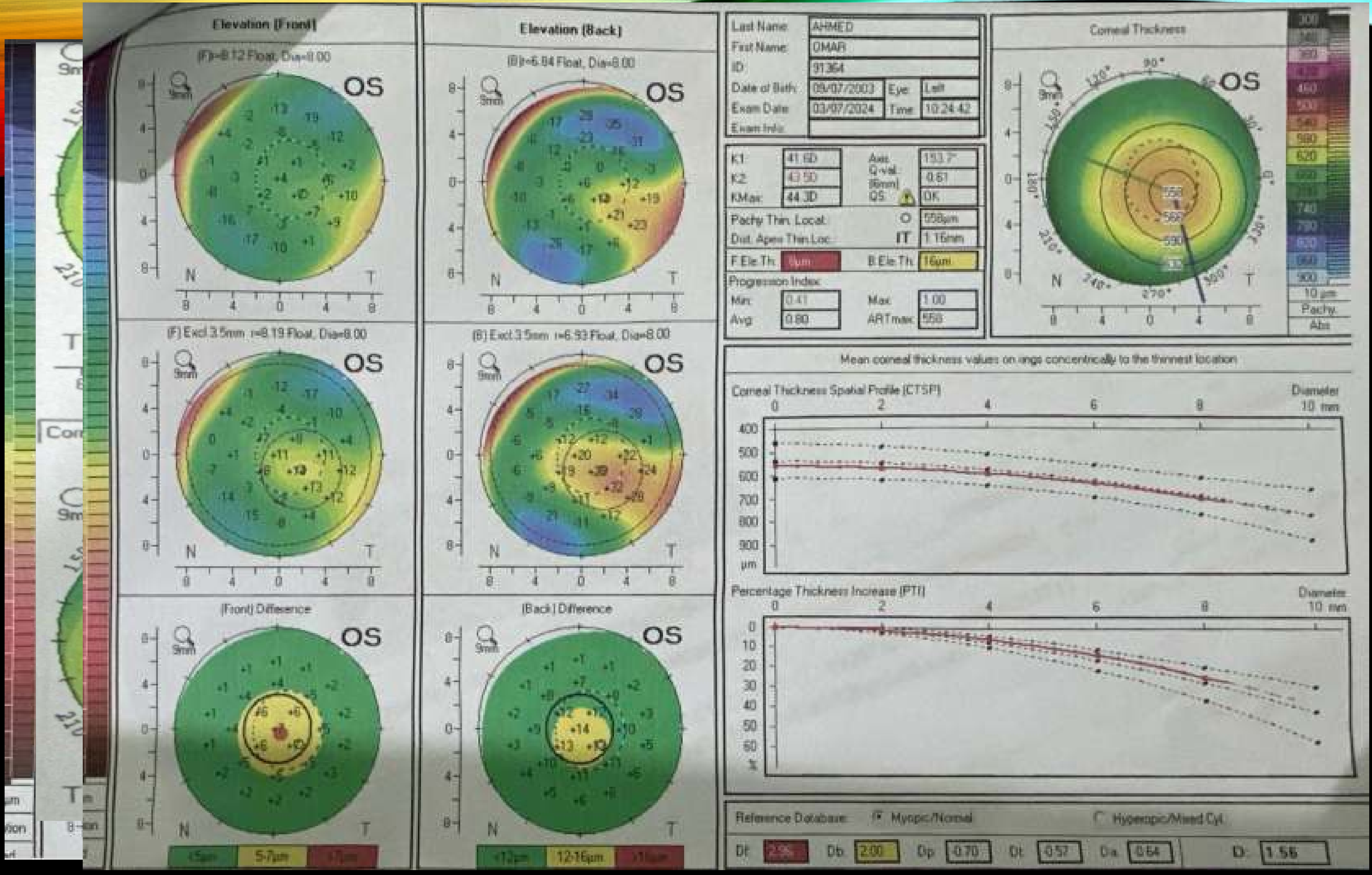
Elevation (Front)
Elevation (Back)
First Name: Roba
Corneal Thickness
Date of Birth 10/05/1999
Eye: Left
Exam Date 01/26/2025
Time: 13:21:41
Exam Info
BFS=8.15 Float, Dia=8.00
OS
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
SP-A1: 90.9
ARTh 374.7
IOP
IOPnct: 16.0 mmHg
bIOP: 17.8 mmHg
Pachymetry
CCT: 472 µm
SD: 2.49
SD: 0.94
SD: 1.51
SD: 1.11
CBI: 0.73
QS: OK
Q-val. (8mm) -0.43
Q-val. -0.48
Rper 7.03 mm
Rmin 6.32 mm
Astig: 0.4 D
CBI 0.73
untreated post LVC
BAD D 1.70
myopic hyperopic
TBI 0.42
K Max. (Front) 43.5 D
Cornea Volume: 52.8 mm³
HWTW: 11.9 mm
Chamber Volume: 170 mm³
Angle: 34.9°
A. C. Depth (Int.) 3.02 mm
Pupil Dia: 2.93 mm
Diameter 10 mm
Literature

DIFFERENT SCENARIOS CASE 6→___

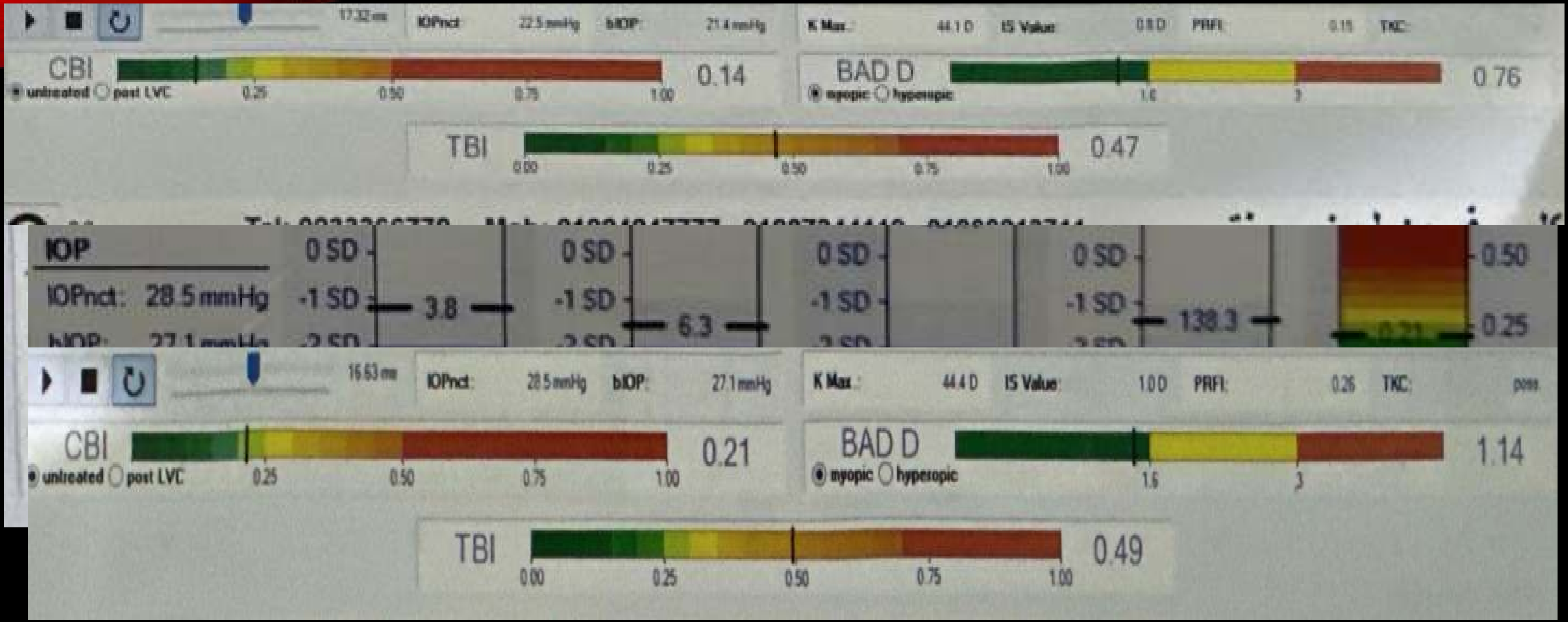


54312
Date of Birth: 10/12/1977
Eye: Left
Exam Date: 07/10/2024
Time: 12:54:48
Axial / Sagittal Curvature (Front)
Elevation (Front)
BFS=8.00 Float, Dia=8.00
OS
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI
SP-A1: 101.5
ARTh: 467.8
IOP
IOPnct: 15.0 mmHg
bIOP: 15.2 mmHg
Pachymetry
CCT: 521 µm
SD: 1.13
SD: 0.23
SD: 0.77
SD: 0.55
CBI: 0.49
4.7
8.3
467.8
101.5
IOPnct: 16.5 mmHg
bIOP: 16.5 mmHg
K Max.: 44.7 D
IS Value: 1.6 D
PRFI: 0.56
TKC: KC 1
CBI 0.75
untreated
post LVC
BAD D 2.65
myopic
hyperopic
TBI 0.99
K Max (Front): 44.2 D
Cornea Volume: 56.1 mm³
HWTW: 11.0 mm
Chamber Volume: 190 mm³
Angle: 33.6 °
A. C. Depth (Int.): 3.01 mm
Pupil Dia: 3.28 mm

DIFFERENT SCENARIOS CASE 7→_

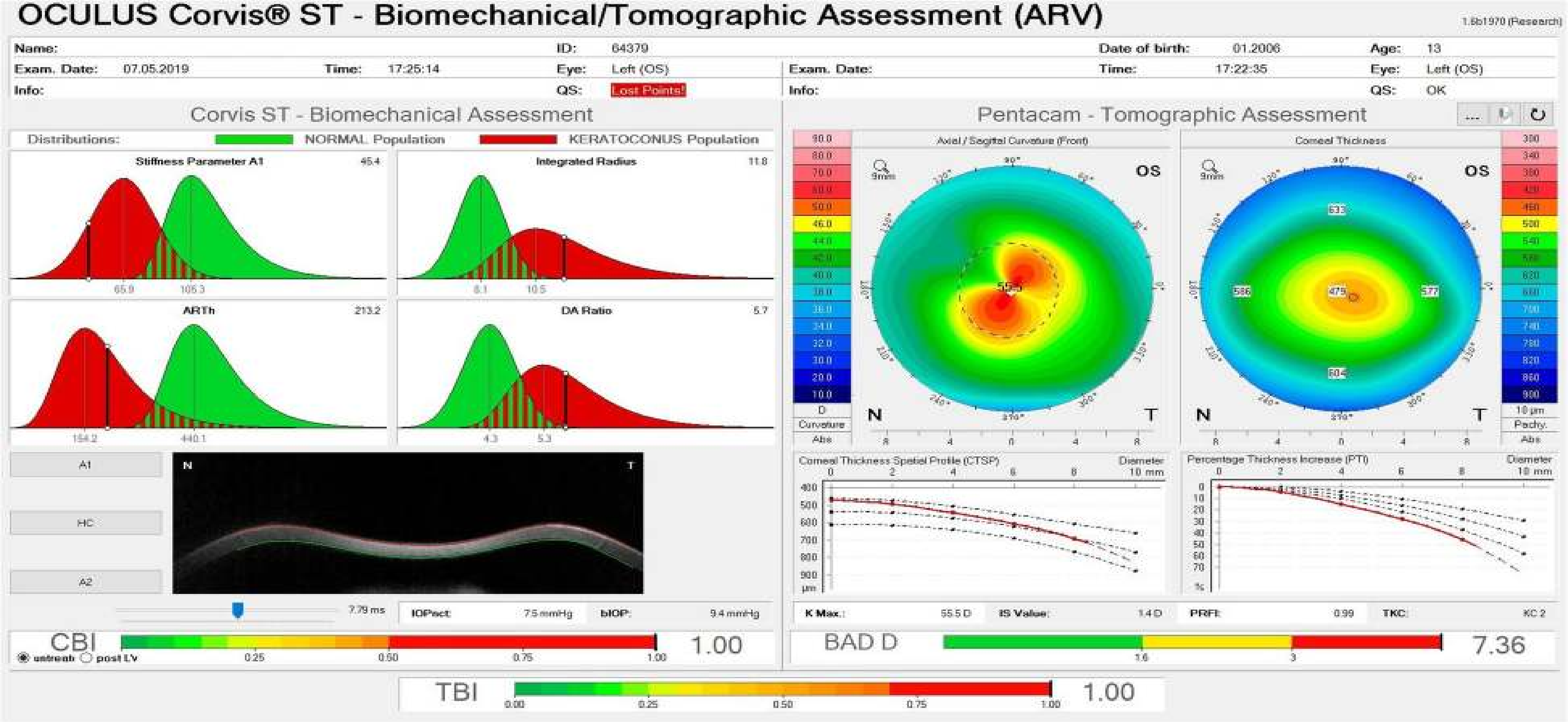


Elevation (Front)
Elevation (Back)
Last Name AHMED
First Name OMAR
ID 31364
Date of Birth 09/07/2003
Eye Left
Exam Date 03/07/2024
Time 10:24:42
Exam Info
Corneal Thickness
OS
K1 41.6D
K2 43.50
KMax 44.3D
Axis 153.7°
Q-val. (6mm) -0.61
QS OK
Pachy Thin. Locat. 558µm
Dist. Apex Thin Loc. 1.16mm
F.Ele.Th 9µm
B.Ele.Th 16µm
Progression Index
Min 0.41
Max 1.00
Avg 0.80
ARTmax 558
(F) Excl 3.5mm r=8.19 Float, Dia=8.00
(B) Excl 3.5mm r=6.93 Float, Dia=8.00
Mean corneal thickness values on rings concentrically to the thinnest location
Corneal Thickness Spatial Profile (CTSP)
Diameter 10 mm
Percentage Thickness Increase (PTI)
(Front) Difference
(Back) Difference
<5µm
5-7µm
<12µm
12-16µm
Reference Database:
Myopic/Normal
Hyperopic/Mixed Cyl.
Df 2.96
Db 2.00
Dp 0.70
Dt 0.57
Da 0.64
D: 1.56

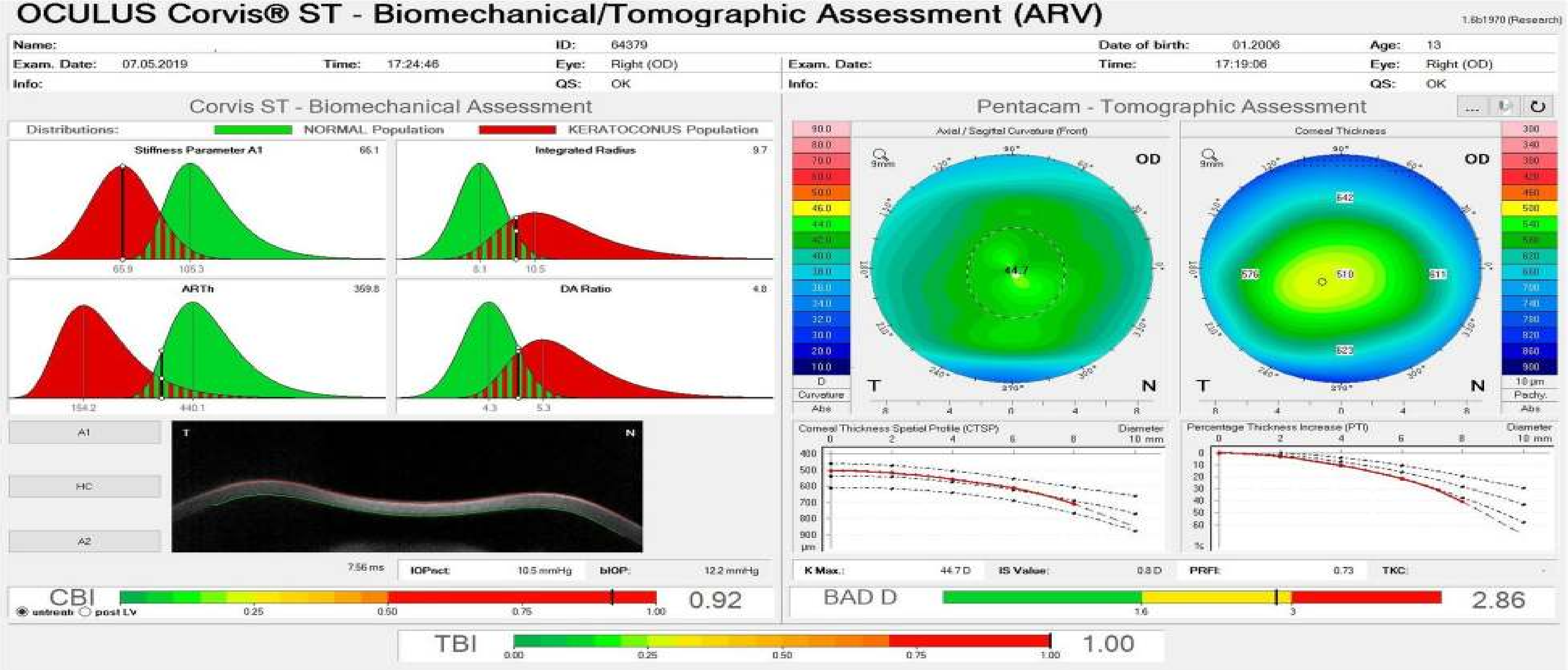


IOPnct: 22.5 mmHg
bIOP: 21.4 mmHg
K Max.: 44.1 D
IS Value: 0.8 D
PRFI: 0.15
TKC:
CBI
0.14
untreated
post LVC
BAD D
0.76
myopic
hyperopic
TBI
0.47
IOP
IOPnct: 28.5 mmHg
0 SD
-1 SD
3.8
6.3
138.3
0.50
0.25
16.63 ms
IOPnct: 28.5 mmHg
bIOP: 27.1 mmHg
K Max.: 44.4 D
IS Value: 1.0 D
PRFI: 0.26
TKC:
CBI
0.21
untreated
post LVC
BAD D
1.14
myopic
hyperopic
TBI
0.49

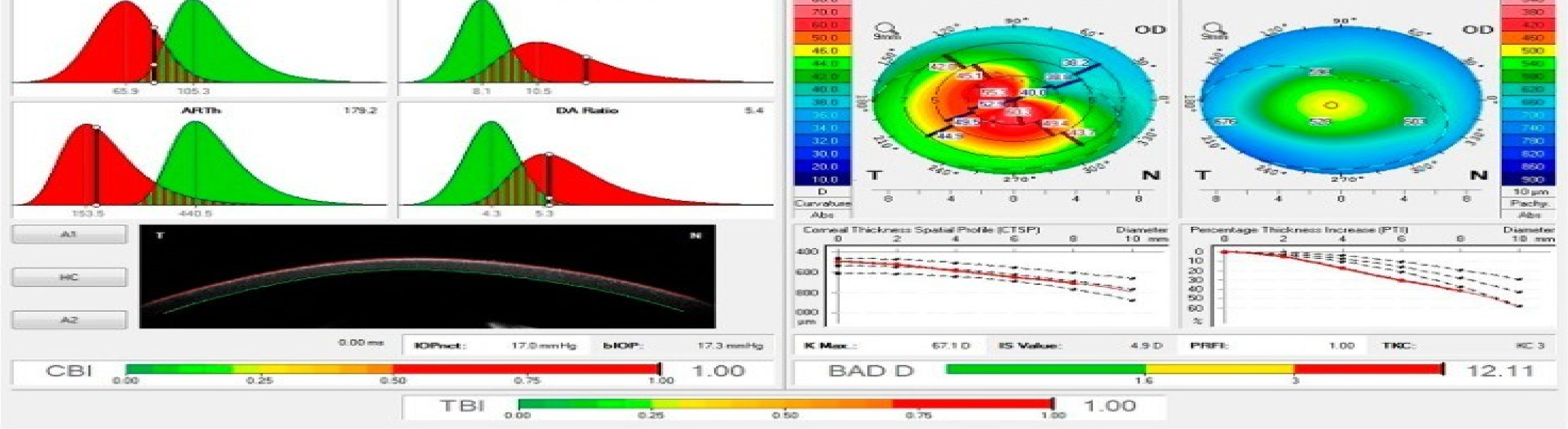
VAE-NT



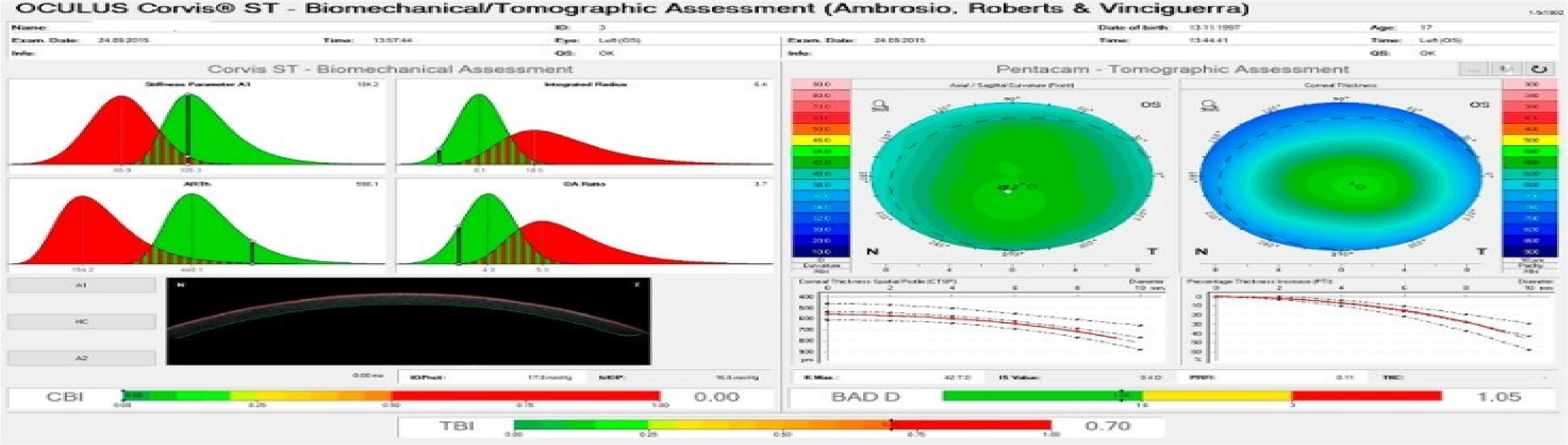
The Ambrósio, Roberts & Vinciguerra (ARV) Display from the VAE-E



The Biomechanical and Tomographic Display showing the Corvis Biomechanical Index (CBI), tomographic biomechanical index (TBI) from the VAE-NT case with uncorrected distance visual acuity of 20/20.

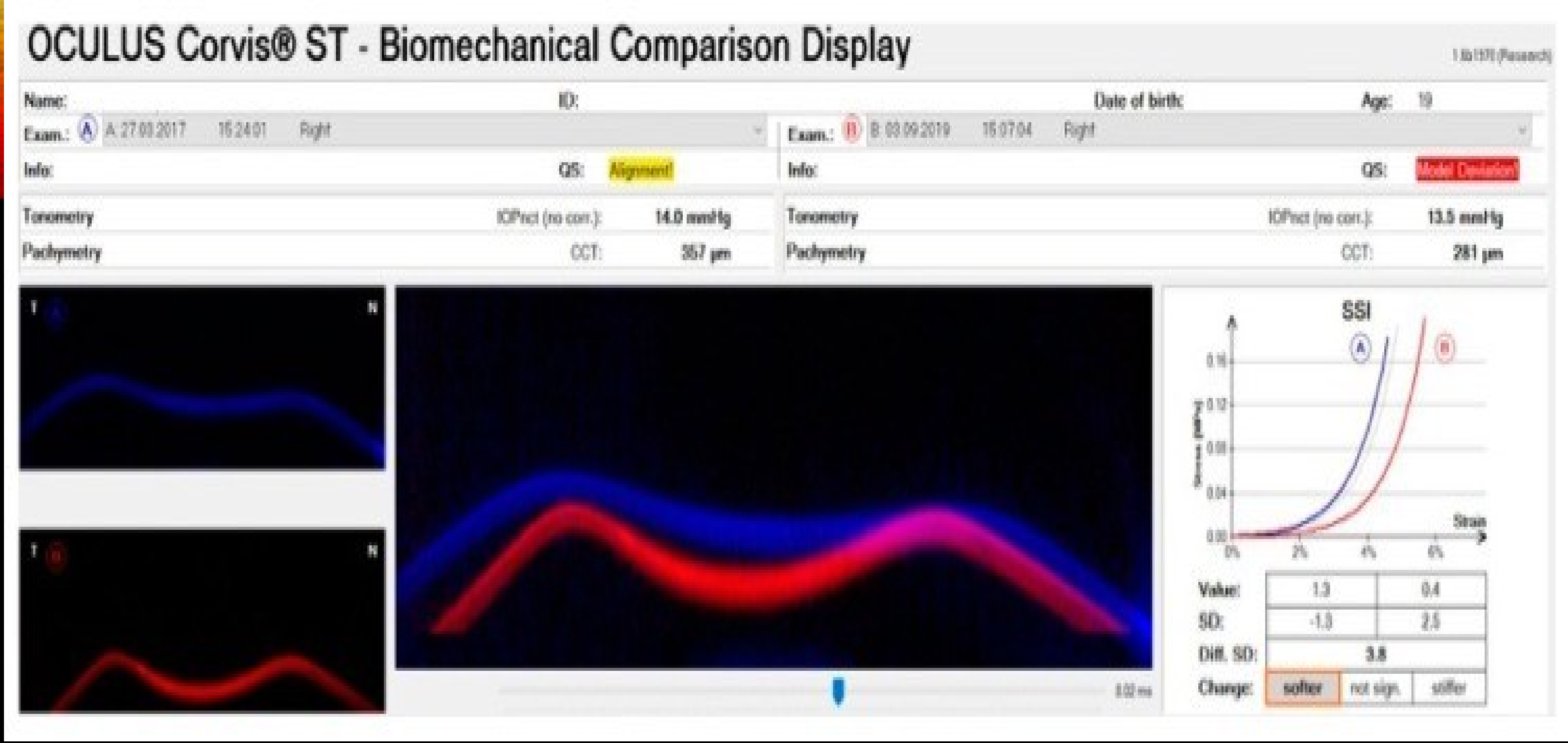

ARTh
179.2
DA Ratio
5.4
OD
A1
HC
A2
IOPnct:
17.0 mmHg
bIOP:
17.3 mmHg
CBI
1.00
Corneal Thickness Spatial Profile (CTSP)
Percentage Thickness Increase (PTI)
K Max.:
67.1 D
IS Value:
4.9 D
PRFI:
1.00
TKC:
KC 3
BAD D
12.11
TBI
1.00

(A)

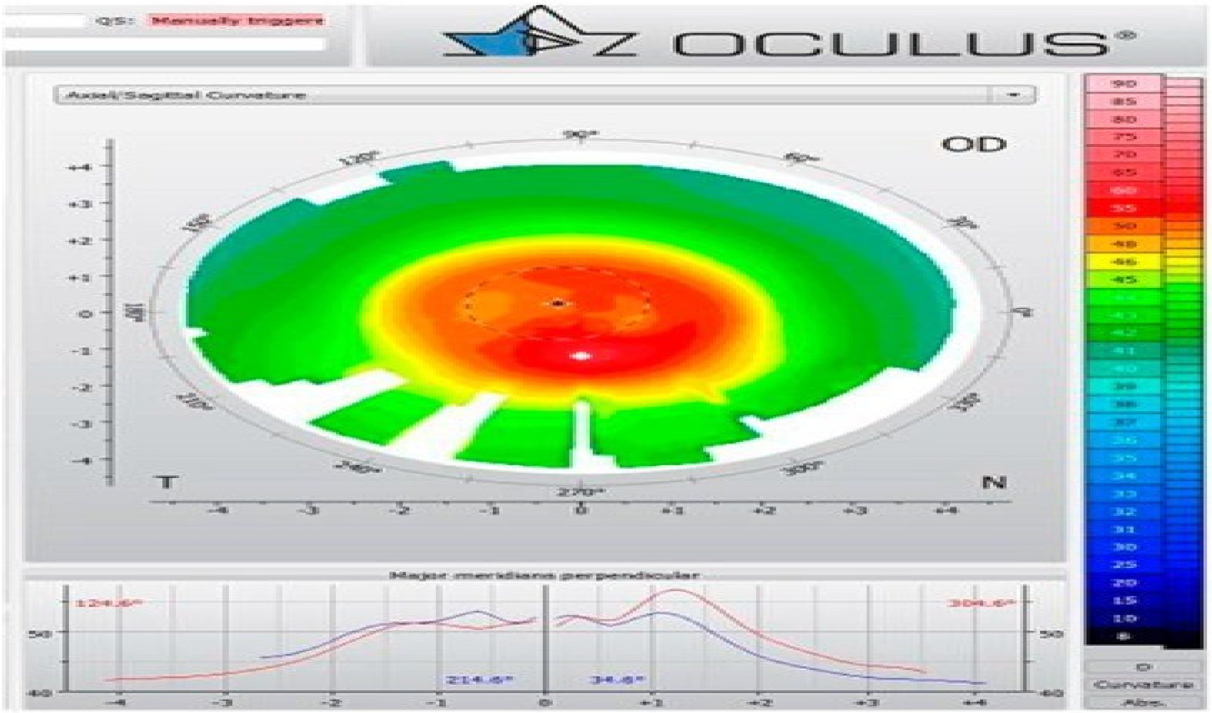

OCULUS Corvis® ST - Biomechanical/Tomographic Assessment (Ambrosio, Roberts & Vinciguerra)
Corvis ST - Biomechanical Assessment
Pentacam - Tomographic Assessment
OS
A1
HC
A2
CBI
0.00
BAD D
1.05
TBI
0.70

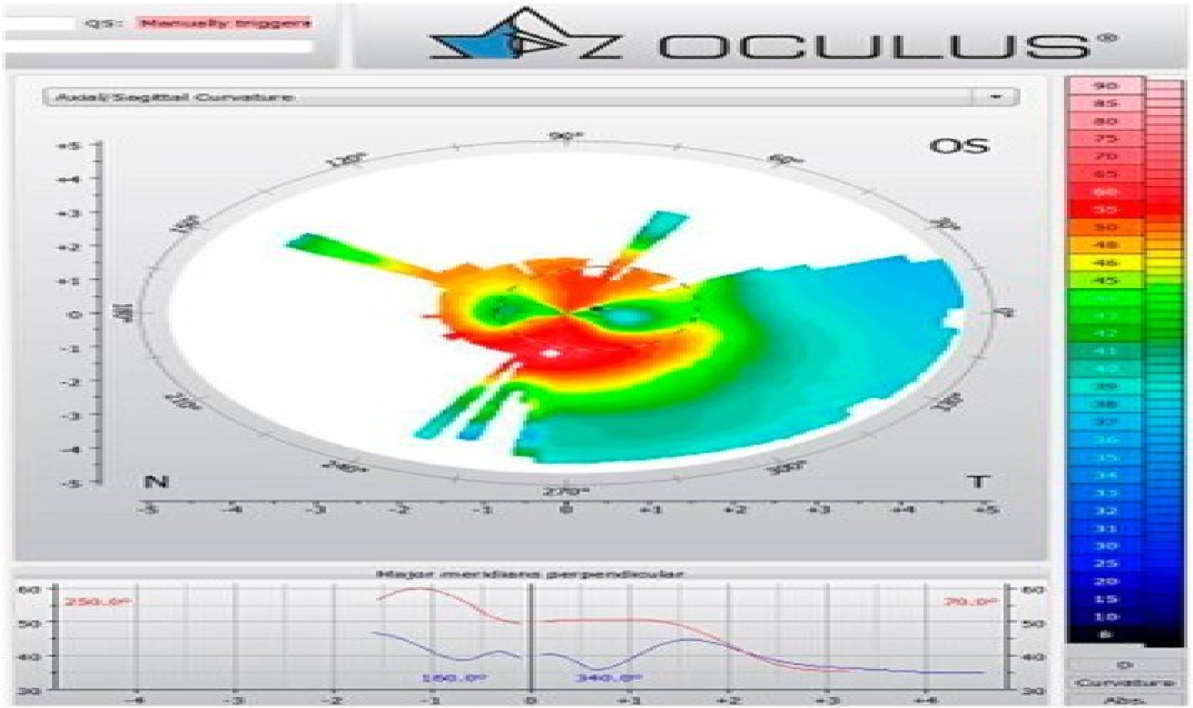
Author / Reference	NE (n)	Clin Ectasia (n)	Cut-off	Sensitivity (%)	Specificity (%)	AUC	VAE-NT	Cut-off	Sensitivity (%)	Specificity (%)	AUC	Observation
Steinberg J et al. [71]	105	96	–	98.00	100	0.998	32	0.11	72.00	71.00	0.825	VAE NTT: 18 eyes Sensitivity: 67% / Specificity: 65% / AUC: 0.732
Kataria P et al. [62]	100	100	> 0.63	99.00	100	0.995	100	> 0.09	82.00	78.00	0.793	–
Ferreira-Mendes J et al. [16]	312	118	0.335	94.40	94.90	0.988	57	0.295	89.50	91.00	0.96	–
Chan TCY et al. [72]	37	23	–	–	–	–	–	0.16	84.40	82.40	0.925	–
Sedaghat MR et al. [61]	137	145	> 0.49	100	100	1.000	–	–	–	–	–	–
Koc M et al. [73]	35	–	–	–	–	–	21	0.29	67.00	86.00	0.790	–
Koh S et al. [74]	70	–	–	–	–	–	23	> 0.259	52.17	88.57	0.751	–

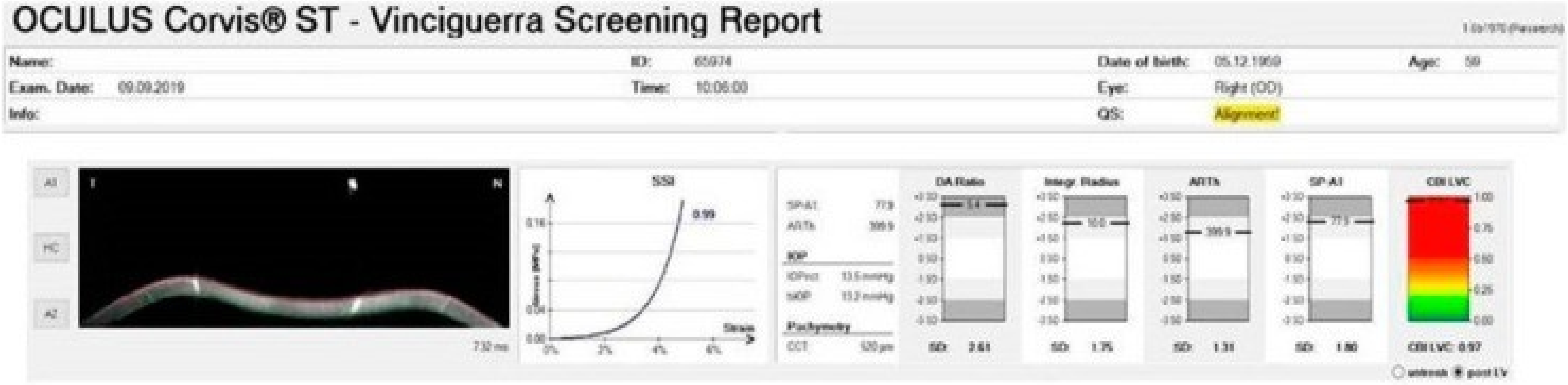
NE= normal eyes, *VAE-NT*= very asymmetric eyes with normal topography, *NTT*= eyes with normal topography and tomography, *AUC*= area under the receiver operating characteristics curve



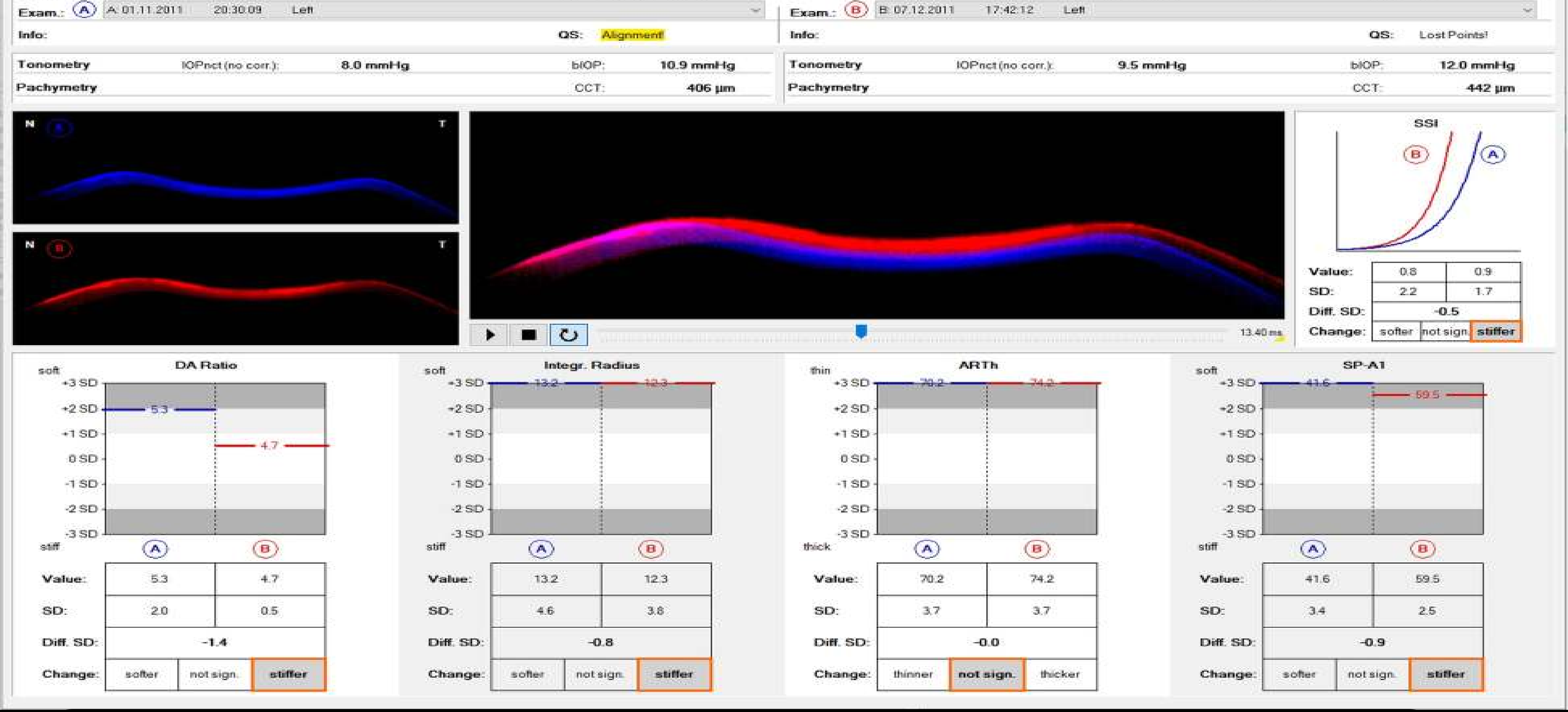
Biomechanical comparison displayed from the right eye in 2017 (Exam A) and 2019 (Exam B). Note that the cornea becomes softer and thinner, considering the first and second consultations, as noted comparing the variables DA ratio, integrated radius, SP A1, and ART h.


OCULUS
QS: Manually triggered
Axial/Sagittal Curvature
OD
90°
120°
60°
150°
30°
0°
210°
330°
240°
300°
270°
T
N
Major meridians perpendicular
124.6°
304.6°
214.6°
34.6°
Curvature
Abs.


OCULUS
QS: Manually triggered
Axial/Sagittal Curvature
OS
90°
120°
60°
150°
30°
0°
210°
330°
240°
300°
270°
N
T
Major meridians perpendicular
250.0°
70.0°
160.0°
340.0°
Curvature
Abs.


OCULUS Corvis® ST - Vinciguerra Screening Report
Name:
ID: 65974
Date of birth: 05.12.1959
Age: 59
Exam. Date: 09.09.2019
Time: 10:06:00
Eye: Right (OD)
Info:
QS: Alignment!
AI
HC
AZ
T
N
7.32 ms
SSI
0.99
Strain
SP-A1 77.9
ARTh 399.9
IOP
IOPnct 13.5 mmHg
bIOP 13.2 mmHg
Pachymetry
CCT 520 µm
DA Ratio
Integr. Radius
ARTh
SP-A1
CBI LVC
SD: 2.61
SD: 1.75
SD: 1.31
SD: 1.80
CBI LVC: 0.97
untreated
post LV

FOLLOW UP



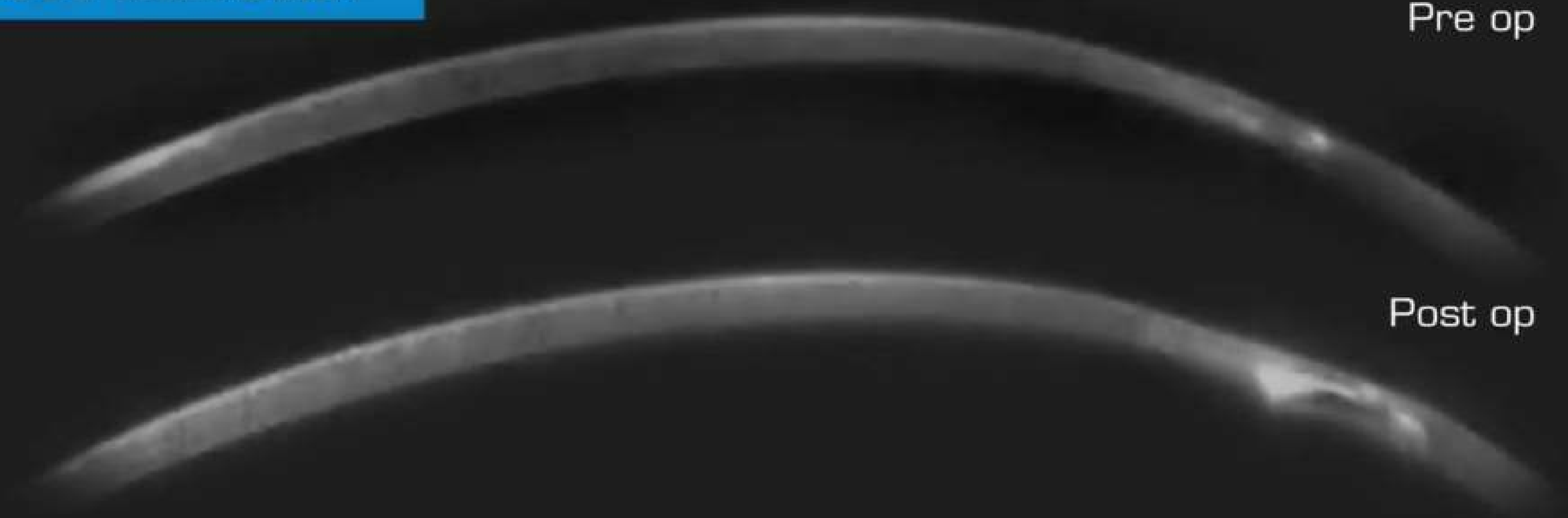
Comparative Corvis ST display before (A in red) and after CXL (B in blue), including the overlap image at higher deformation, the SSI (Stress-Stain Index), and the stress-strain curves, along with comparative DA ratio, integrated radius, and the Stiffness Parameter at first Applanation (SPA1) indicating stiffer behavior after the procedure.

Pre- and Post CLX in keratoconus

Greater stability post op

Effect of corneal rings

Less oscillation



Provided by Renato Ambrósio Jr

OCULUS®

HOME MESSAGES

- Biomechanics would be useful in several clinical applications, including management of, ectasia risk-profiling, and the degree , depth of CXL and precise intraocular pressure measurements based on biomechanically corrected intraocular pressure (bIOP) readings.

- The integration of tomographic and biomechanical data has demonstrated potential to improve the accuracy of detection of ectatic disease and identify susceptibility to develop this complication after laser vision correction .

- Further integration with other data, such as ocular wavefront, axial length, segmental layered (epithelium) and microlayer (Bowman) tomography is also promising.

Thank You!
谢谢
Gracias
Merci
धन्यवाद
תודה
Asante
Thank you
Grazie
Obrigado
Danke
شكرا
Спасибо
ありがとう