Role Of
Epithelial Thickness Mapping
In Diagnosis Of Ectasia

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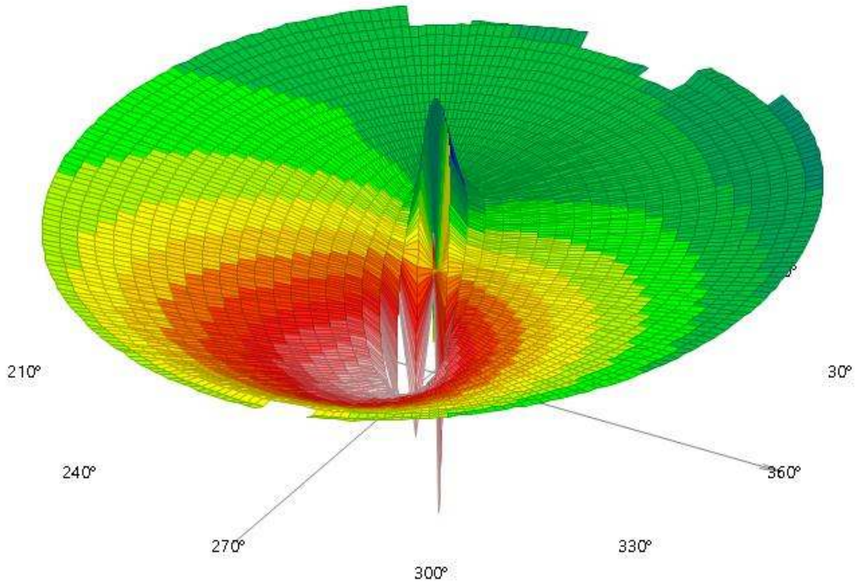
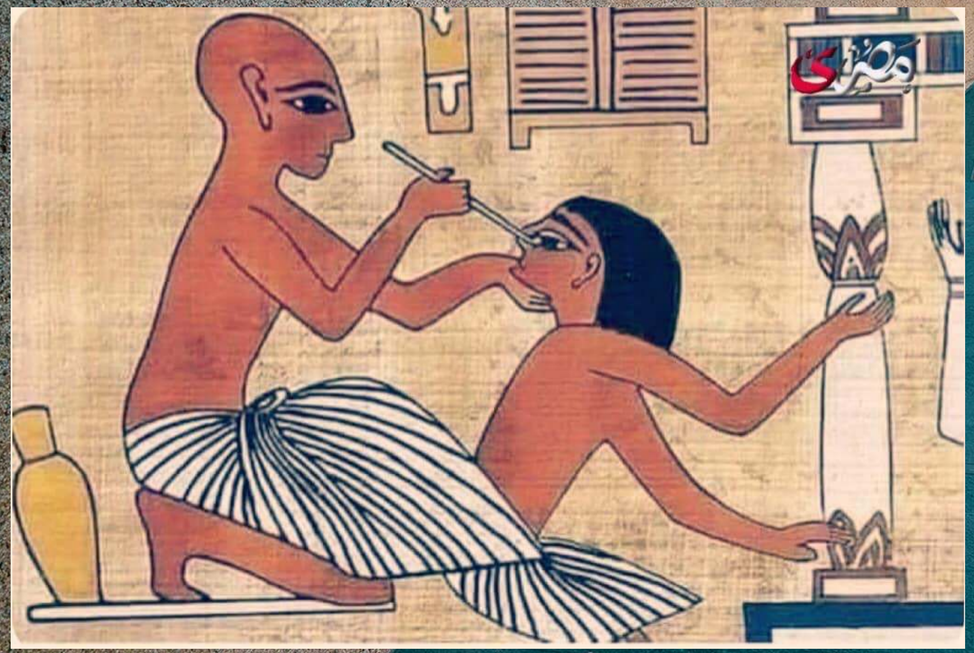


Axial posterior curvatur

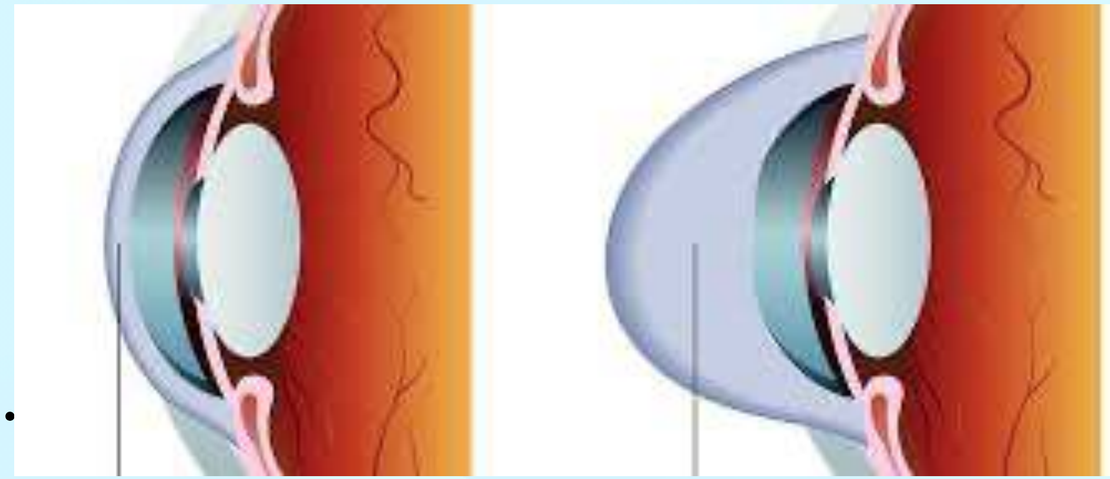
No Financial interest



High definition AS-OCT MS 39

Introduction:

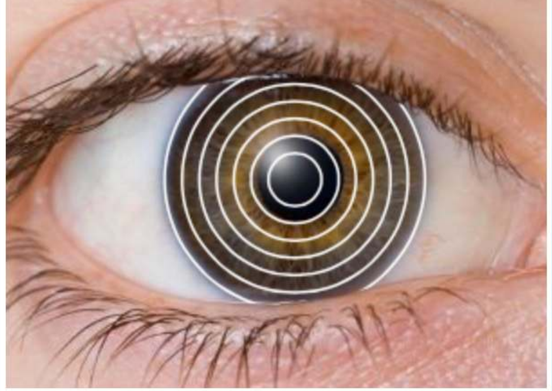
Corneal Ectasia (Keratectasia)

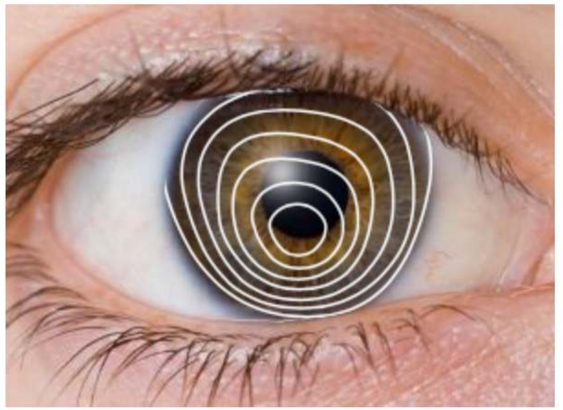


- Keratectasia= Abnormal bulging of the cornea.
- It could be primary (genetic) as in Keratoconus, or secondary; acquired or iatrogenic (post-LASIK ectasia).
- it's also reported to occur rarely after Keratoplasty & Radial Keratotomy (RK).
- The main pathological changes are due to weakening of the stromal collagen.
- So that, it is very crucial to diagnose it at early stage to prevent vision-loss as well as making the treatment and rehabilitation more successful .

Keratectasia

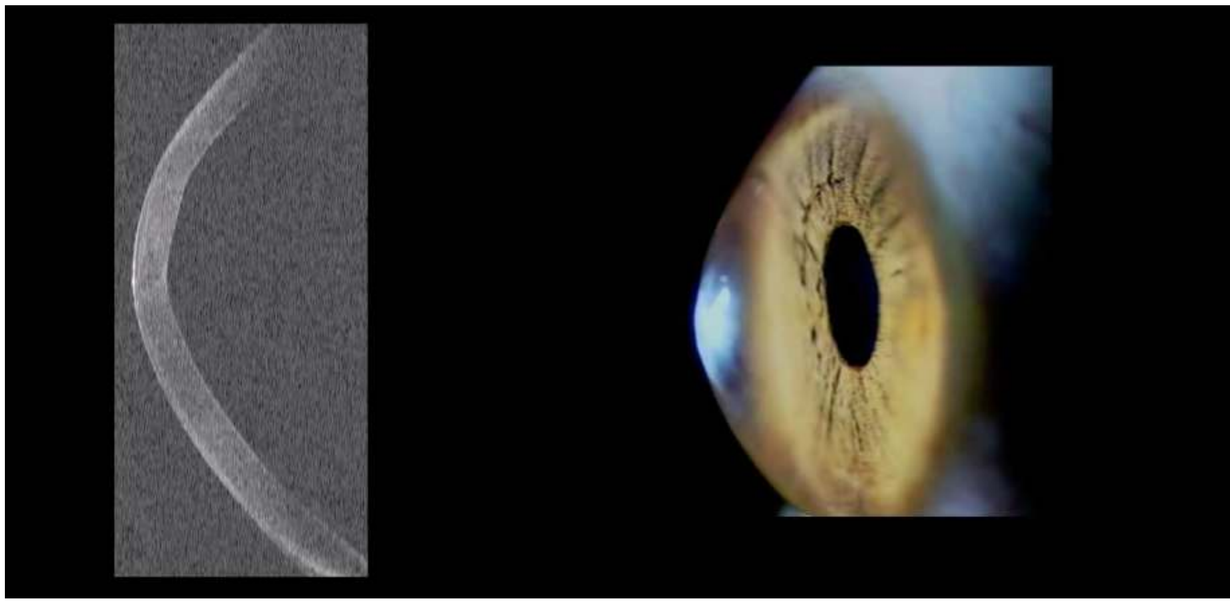
Keratectasia = Kerectasia = Corneal ectasia





- It is defined as an abnormal protrusion of the cornea, either primarily as a genetic disease, or secondary to trauma, scarring or progressive thinning as well as latrogenic ectasia due to previous corneal surgery.

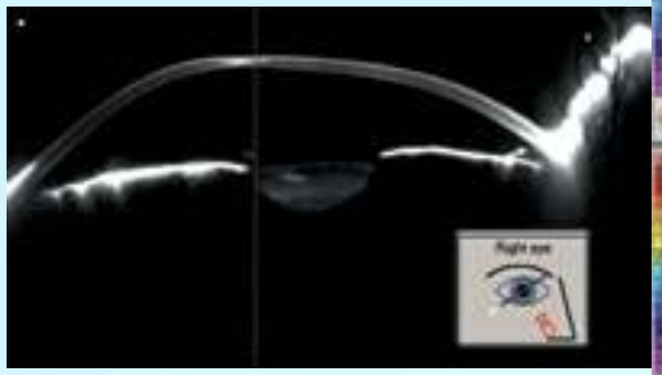
- It is a group of uncommon, non-inflammatory eye disorders characterized by unilateral or bilateral thinning of the central, paracentral or peripheral cornea.

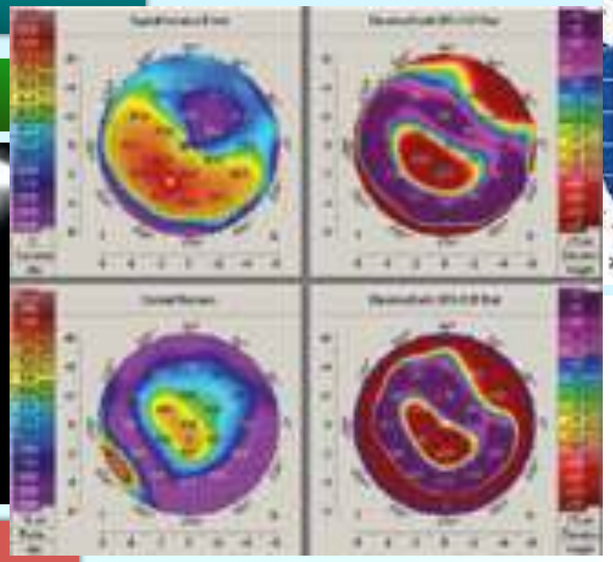


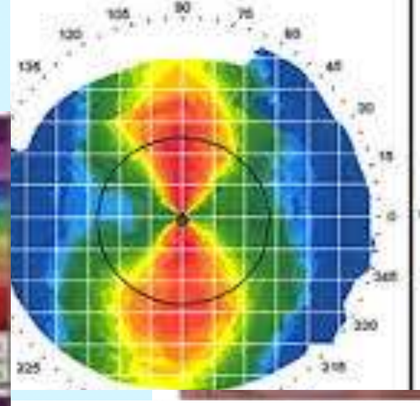
- It's either Primary (KC, KG, PMD, TMD)
  or Acquired (after corneal surgery)

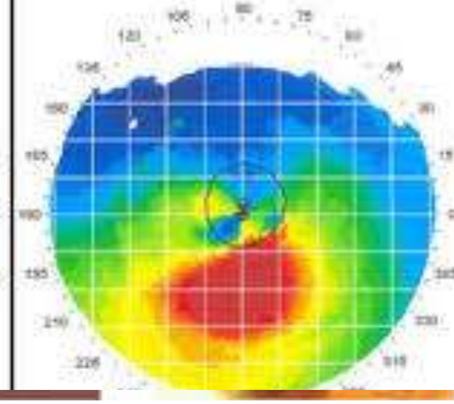
Primary Ectasia = Keratoconus +++

Post laser-based keratorefractive procedures



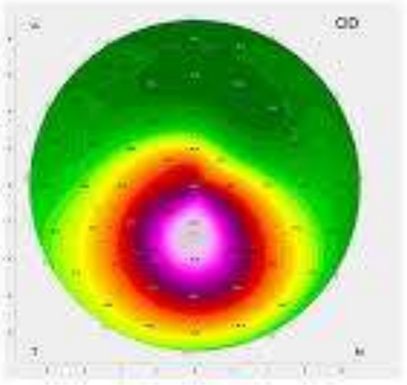


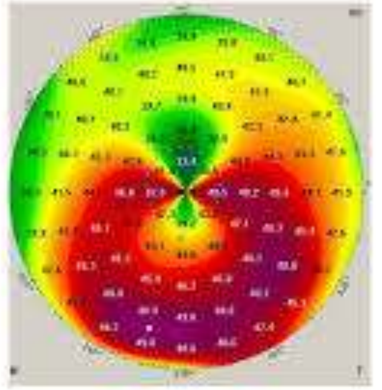




Keratoconus

PMD





Incisional keratorefractive procedures

Radial Keratotomy

Astigmatic Keratotomy

Post keratoplasty ectasia (Recurrent KC)

Patel et al; 2008 reported cases 5-7 yrs after KP for KC

Patel et al 2008 re

a series of cases (2

Post PK ectasia 5-8 y

PKP for keratoconus.

- Nature & site ??

- Treatment ??

Recurrent ectasia in corneal grafts and outcomes of repeat keratoplasty for keratoconus

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ABSTRACT

Aim: To analyse cases of recurrent ectasia in donor corneas after penetrating keratoplasty (PK) for keratoconus.

Methods: Data on 25 patients (36 eyes) with recurrent ectasia were retrospectively analysed in this study. The main outcome measures were time to development of recurrent ectasia after first PK for keratoconus, change in keratometric sphere and astigmatism between final suture removal and development of recurrent ectasia, status of regrafts for recurrent ectasia, and histopathology of grafts excised for recurrent ectasia.

Results: The age at first PK was 32.6 (SD 8.5) years, and ectasia developed 21.9 (7.0) years after PK. The mean keratometric sphere and cylinder increased by 4.2 D and 3.0 D, respectively, between final suture removal and diagnosis of recurrent ectasia. Ectasia was often preceded by thinning without bulging of the recipient stroma at the graft–host junction. Fifteen eyes (13 patients) were regrafted for recurrent ectasia, and histopathology of the excised grafts showed changes characteristic of keratoconus in the donor tissue in all cases. Two regrafts (two eyes of one patient) developed ectasia again, with one eye requiring a third PK to improve vision.

Conclusions: Recurrent ectasia was diagnosed on average two decades after PK. Ectatic changes were often bilateral and occasionally recurred after regrafting, suggesting that host cellular and/or biochemical factors may be responsible. Repeat PK for recurrent ectasia is successful in the intermediate term.

Institutional Review Board approval was obtained for retrospective review of medical data.

Data from patient records were analysed for age at first surgery, time to diagnosis of recurrent ectasia, gender and laterality. Best-corrected visual acuity (BCVA), spectacle-corrected if not routinely wearing a contact lens, as well as refractive and keratometric sphere and astigmatism were recorded.

The original diagnosis of keratoconus was confirmed on the basis of typical clinical signs, including inferior corneal thinning with cone, Vogt striae or Fleischer ring, and ancillary findings on keratometry and topography, if available. The diagnosis of recurrent ectasia after PK was based on clinical findings, such as inferior paracentral corneal thinning, Vogt striae, visible anterior bulge, irregular astigmatism, and computerised topographic findings, as well as by histopathological findings in the excised donor corneal button. Patients with high regular astigmatism on topography and those with inferior thinning restricted to only the recipient side of the graft–host junction were not included. No patients had a history of trauma to the graft that may have resulted in wound dehiscence.

For patients who underwent repeat PK for recurrent ectasia, the excised grafts were cut orthogonal to the cornea immediately adjacent to the region demonstrating maximal ectasia on gross examination. After processing the specimens routinely, 6 µm paraffin step sections taken at 50 µm

Multi-modal imaging in Refractive surgery

Keratectasia screening

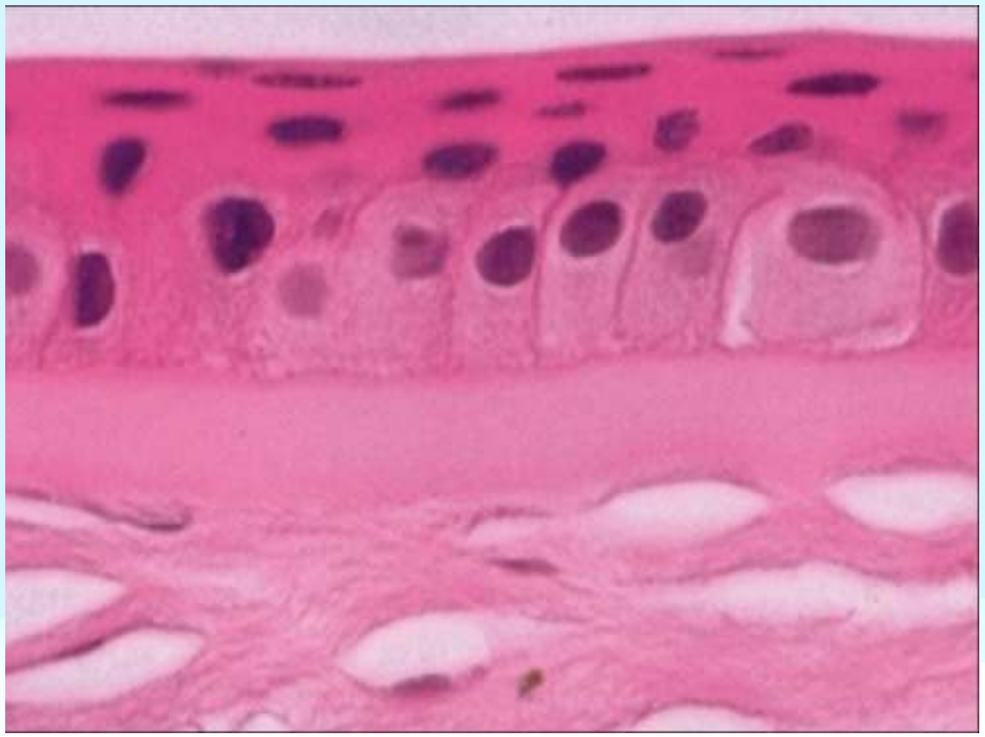
- A larger scale of people (different ages) are seeking for refractive procedures.
- refractive surgery is going more advanced, so that the tools should be more sensitive to help discovering the susceptible individuals to develop ectasia.
- In addition to the high resolution Topo & Tomographers, studying corneal biomechanics is offering an adjuvant tester enhancing the safety profile.
- Recently, ETM is adverted as an essential marker in diagnosis of early rather than established ectasia.

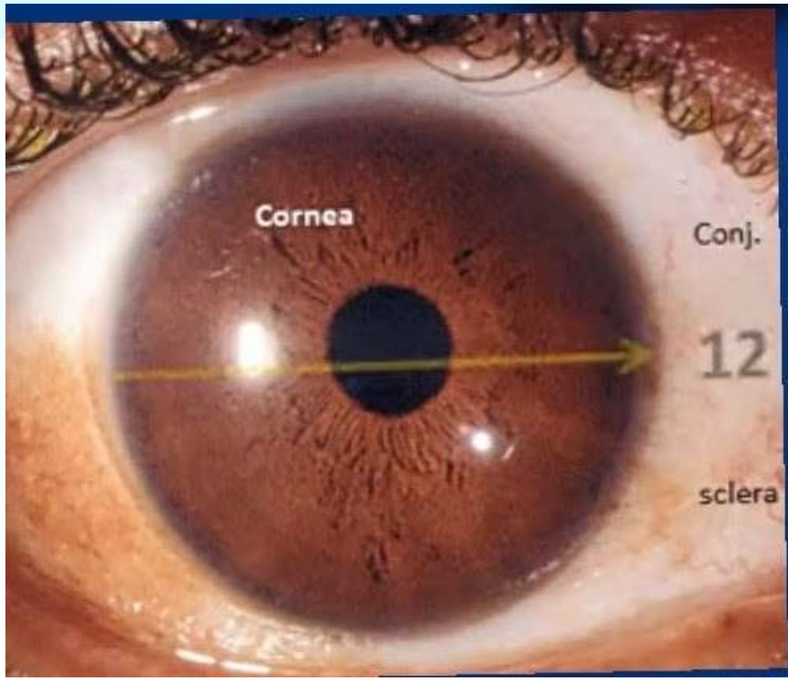
Anatomy of the cornea

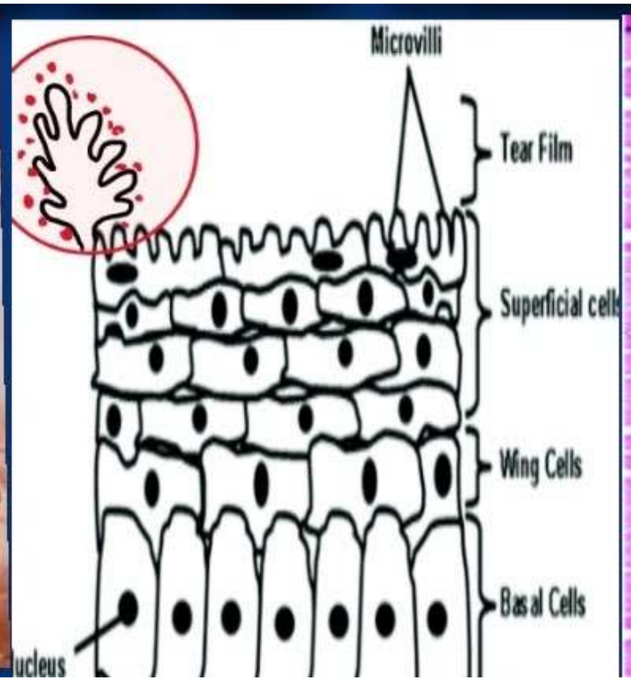
Corneal Epithelium

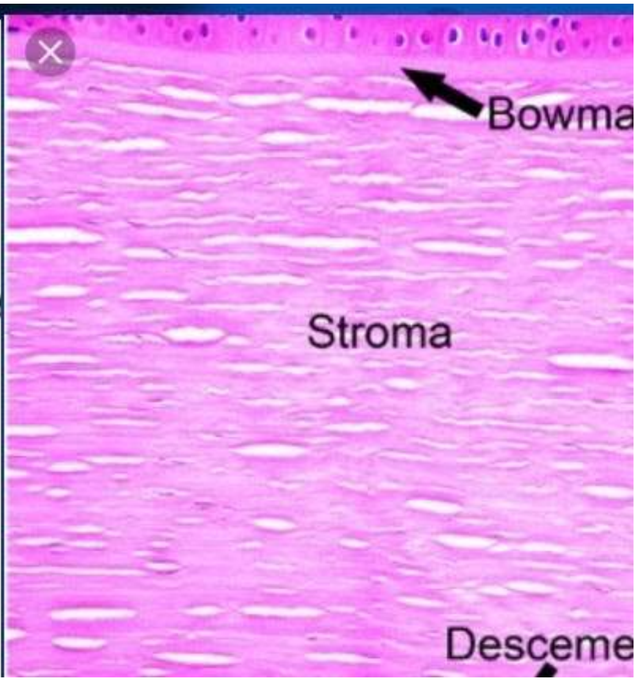
- Cornea consists of 5 layers, which became 6 layers after 2013 (Pre-descemet's (Dua's) Layer) !

- Histology of corneal epithelium: 5-7 layers (basal-cuboidal-squamous cells)





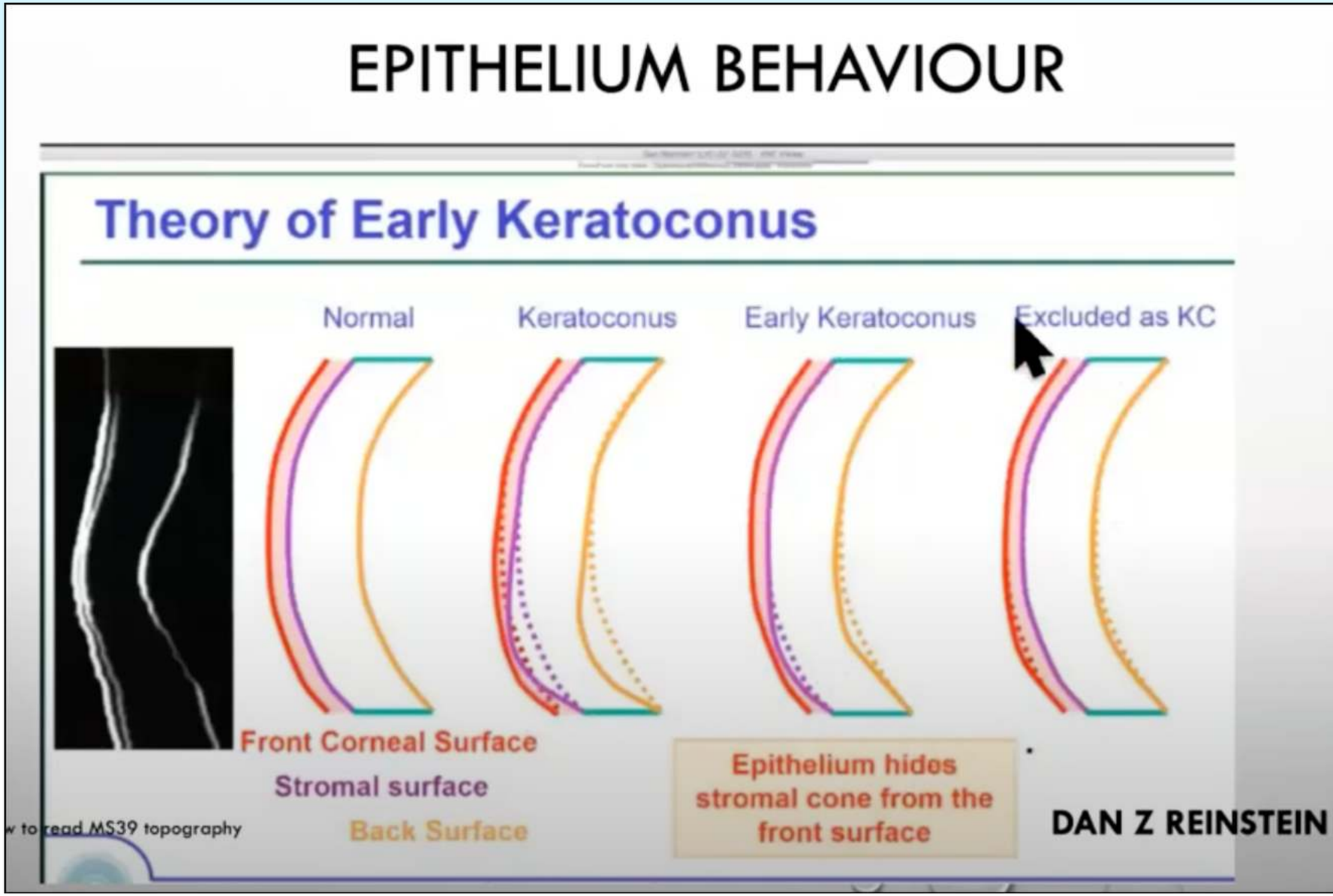




Epithelium behavior in ectasia

The story:

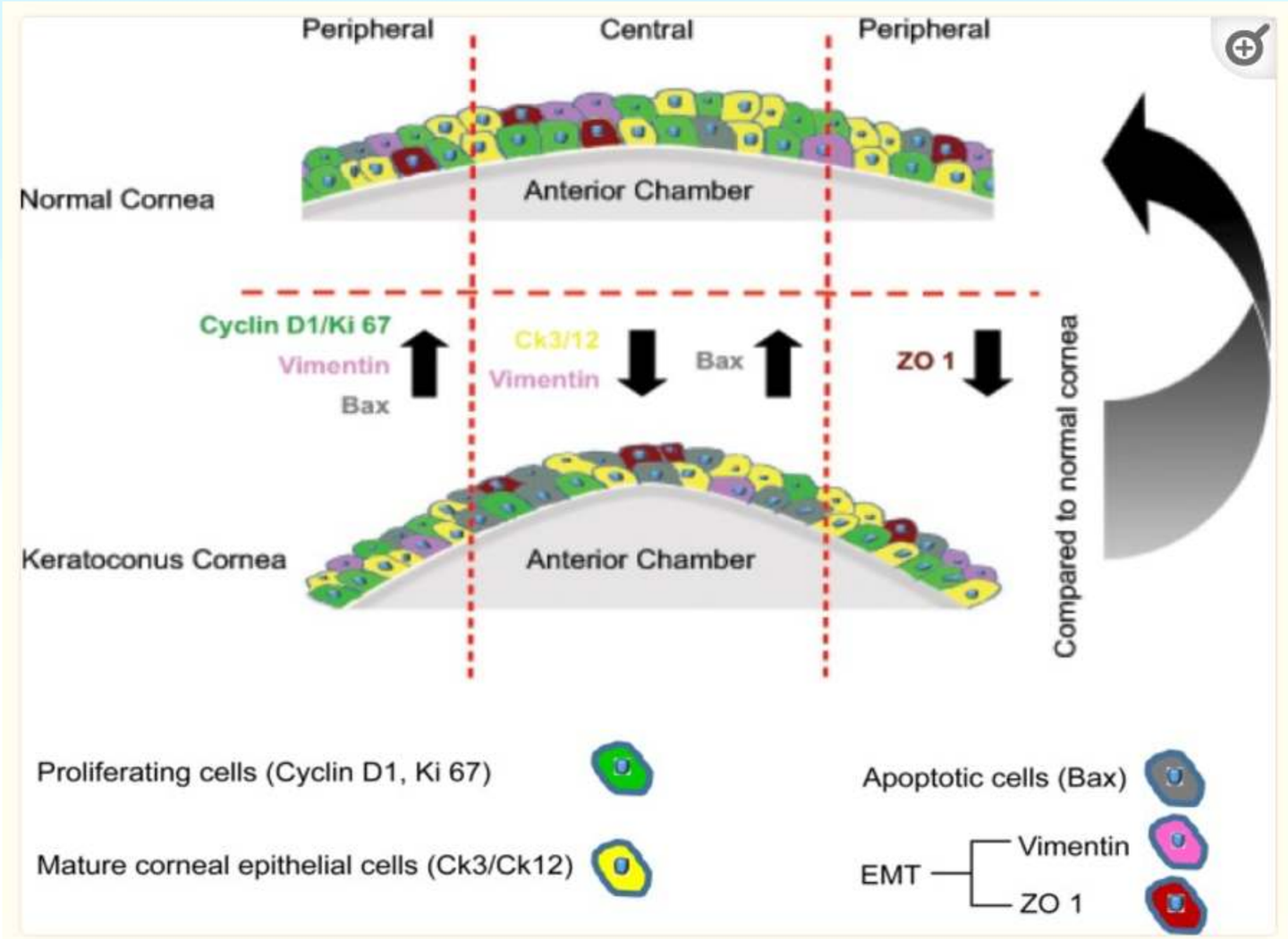
- KC is a posterior disease.
- Epithelium goes in some changes to compensate for cone protrusion.
- So, Epithelium has a masking effect.
- So ETM with specific pattern is an important sign for KC diagnosis & its progression as well.



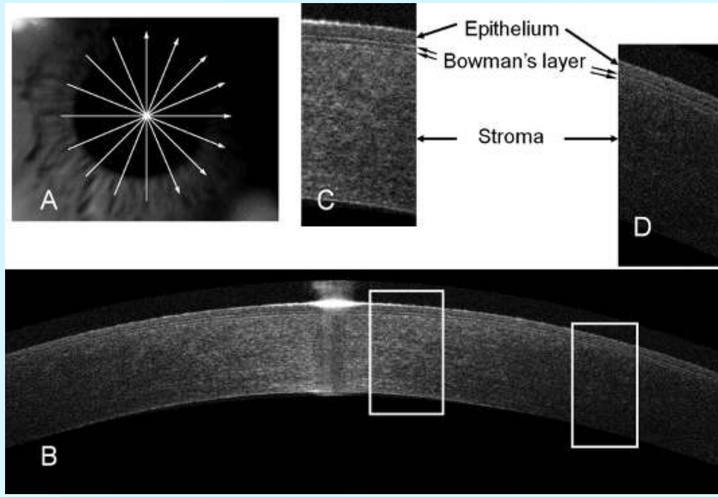
Epithelium histopathology in KC

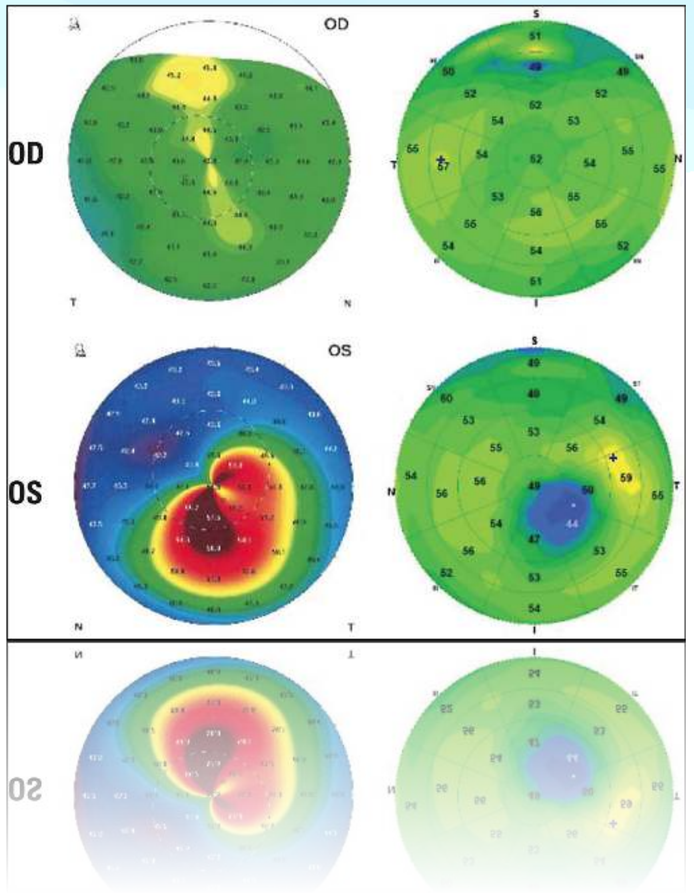
Changes of Epithlium in KC

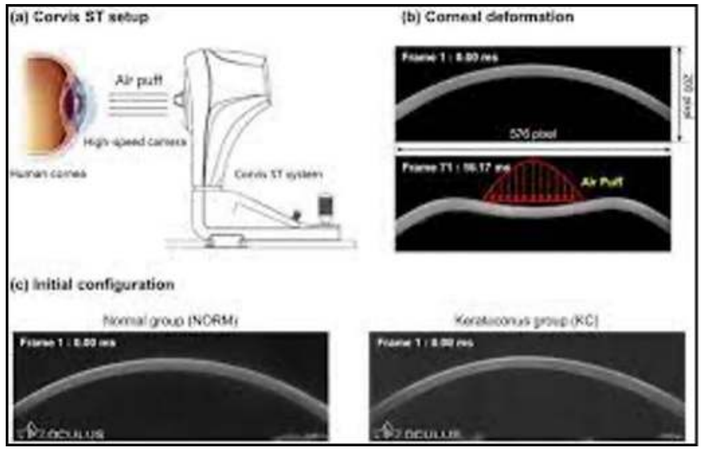
- **Rohett Shetty et al (2013),: Apoptosis of keratocytes is a hallmark of KC.**
- **Thinning in ETM is due to altered turnover of epith cells**
- **Histology = higher numbers of normal epith cells in KC periphery, but at cone apex cells were elongated & arranged in whorl-like fashion.**
- **1ry pathologic issue in the KC = associated apoptosis in stroma & epithelium = thinning of these corneal layers.**



Diagnostic tools for keratectasia







Facts to be considered in diagnosis of PL ectasia

- **Keratometry:** No keratometric value that define ectasia (but irregular astigmatism & steepening in an off-center area; sup. flattening and inf. steepening are typical of ectasia) Ambrosio et al, 2011
- **Elevation maps:** Isolated islands of elevation (ant, post, or both) almost present in PL ectasia. Schlegel et al, 2008
- **Corneal pachmetry:** Relative corneal thinning is a hallmark of corneal ectasia. Atchison et al, 2010
- **Dominant HO aberration** in ectatic cornea is vertical coma
- **Just suspect,** it is not easy to judge, so go for cross-linking without delay, then think !

The common methods

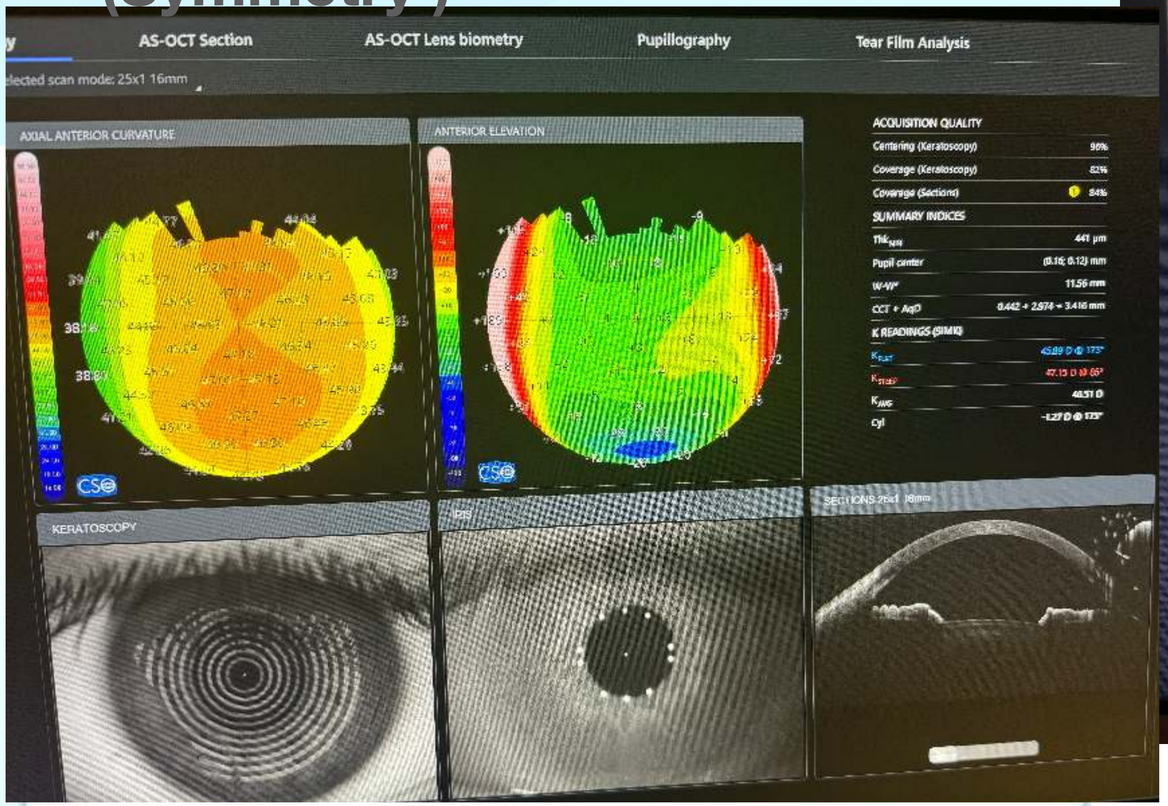
Corneal Topography

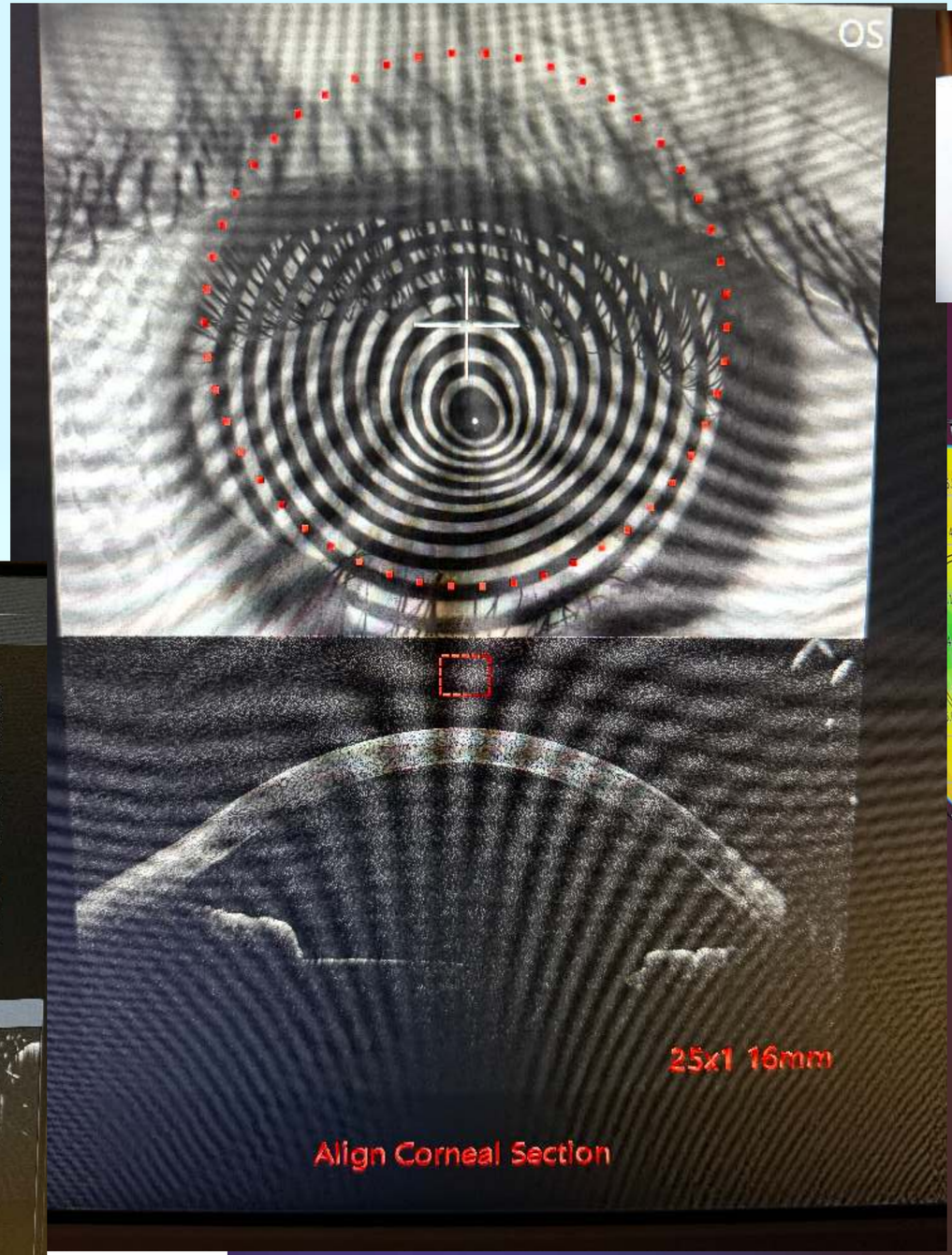
Videokeratoscopy

K Readings

Surface maps

(Symmetry)

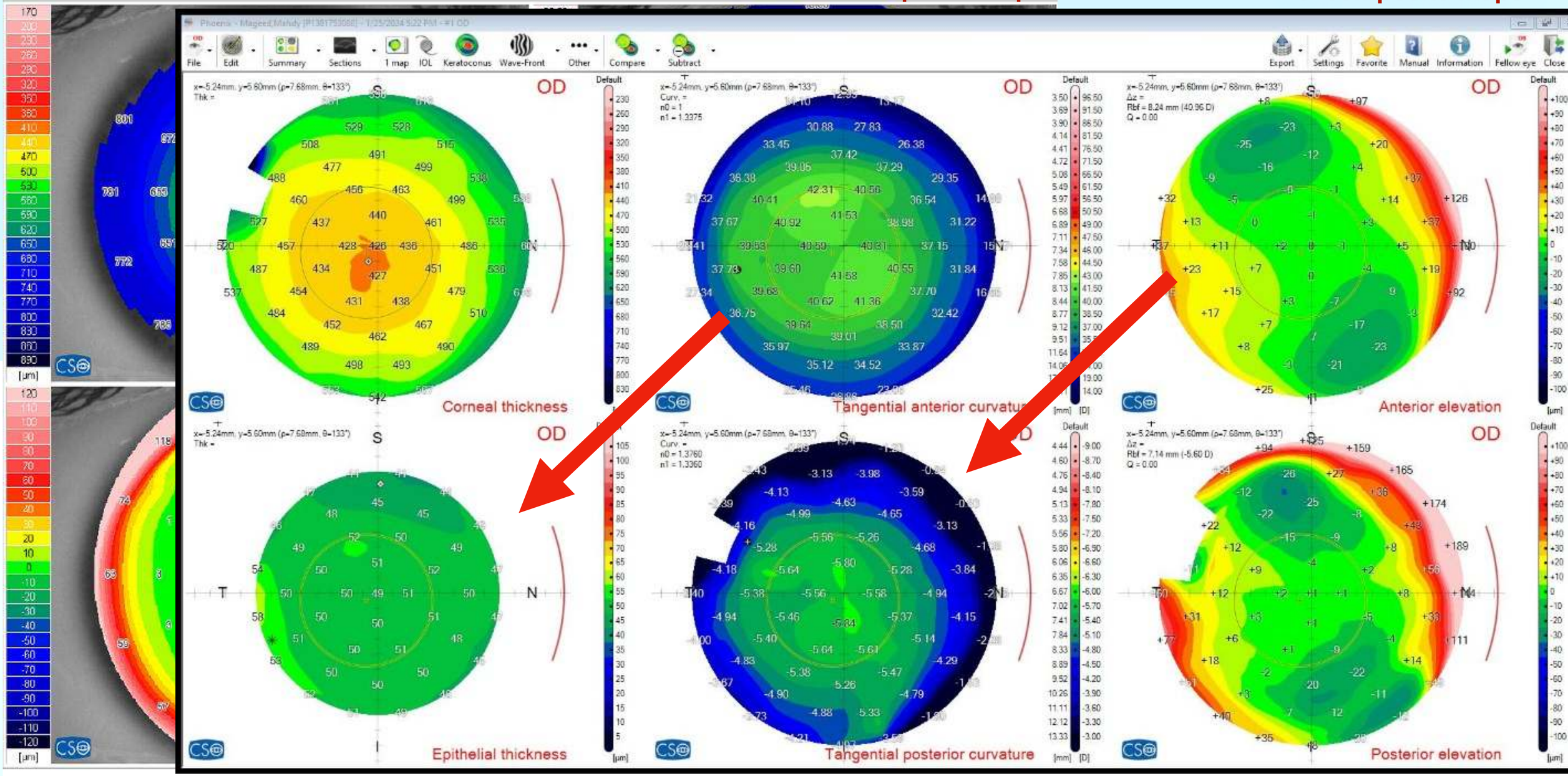




Multi-maps & Correlations → Coincidence (Holland Report)

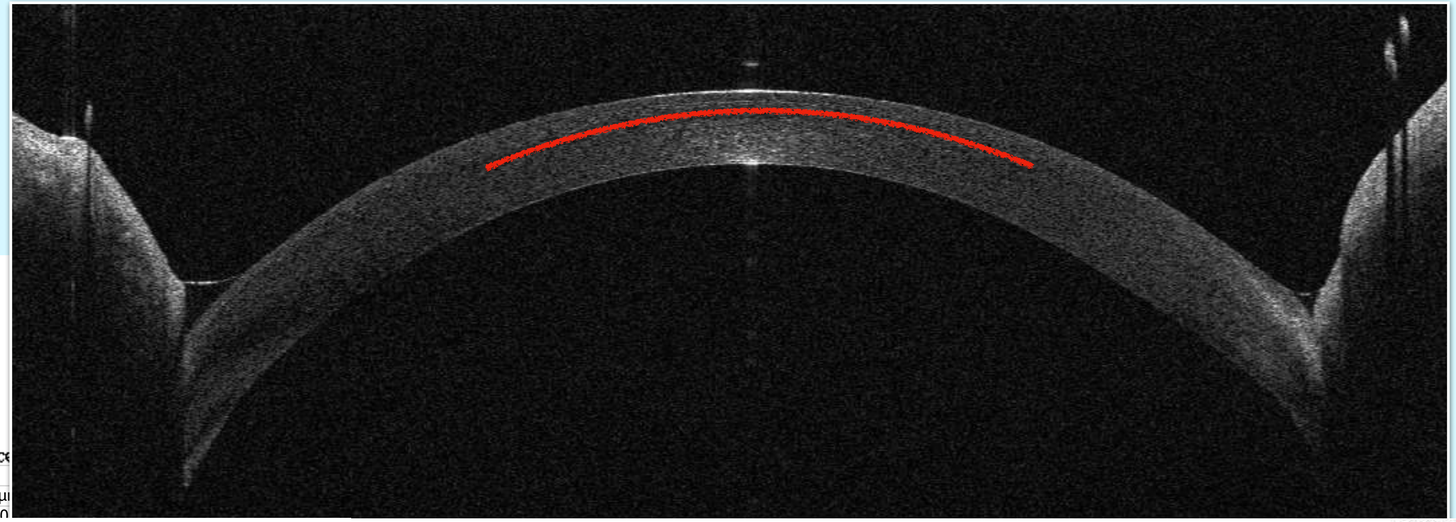
4 composite maps

6 composite maps



Epithelial mapping !!!

Is it really a valuable indicator for ectasia ?!



Maged , Nada
P0704891025
Birthdate: 1/26/2007

AS-OCT Corneal Mapping
12/19/2023 6:24 PM

S

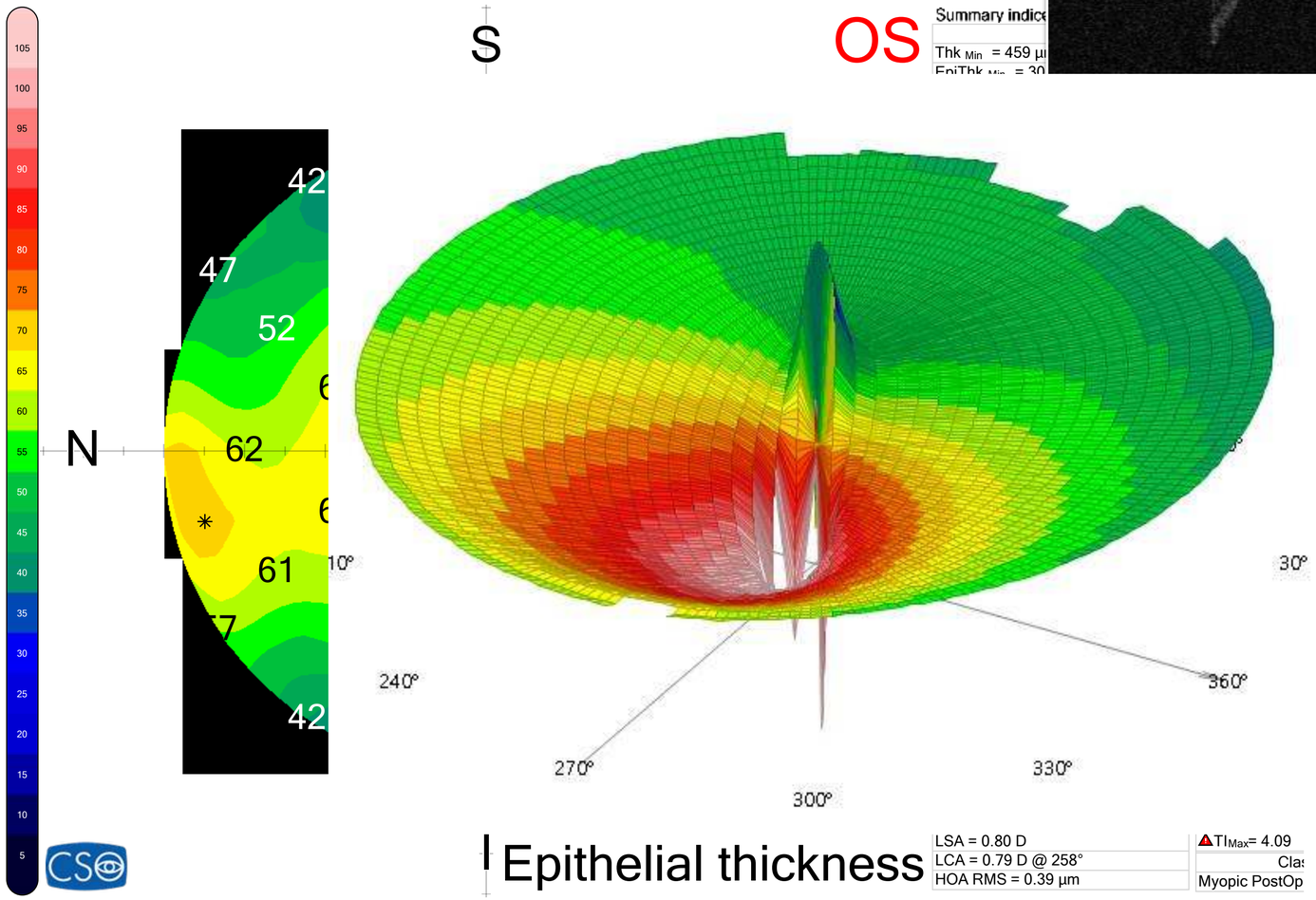
OS

Summary indice

Thk Min = 459 µ

EpiThk Min = 30

Default



Epithelial thickness

LSA = 0.80 D
LCA = 0.79 D @ 258°
HOA RMS = 0.39 µm

TI Max = 4.09

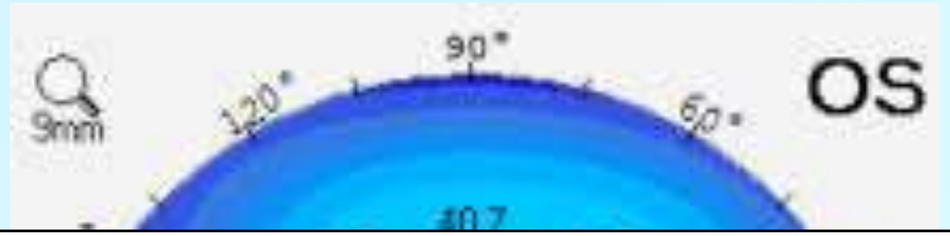
Cla

Myopic PostOp

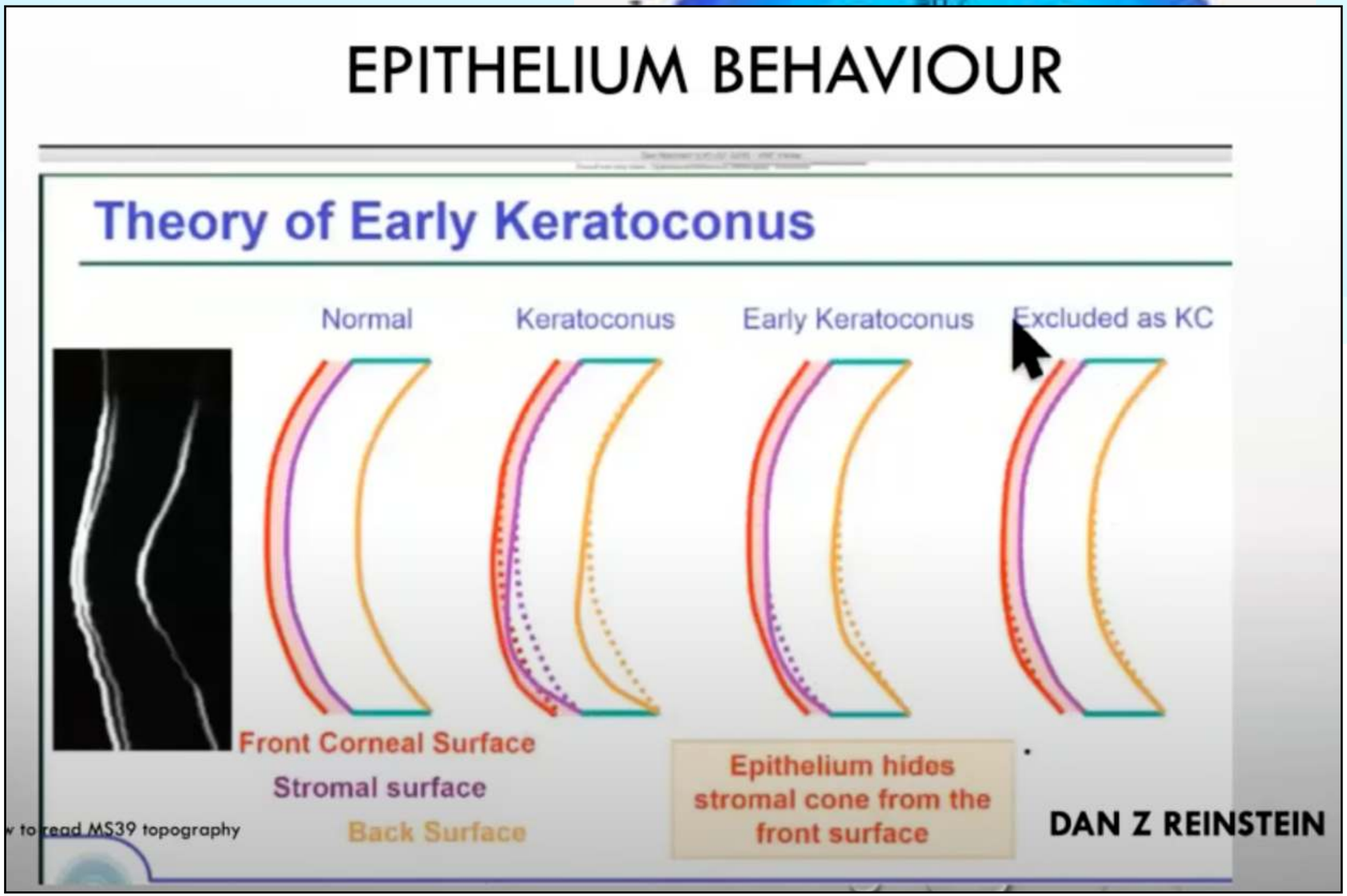
Epithelial thickness

Epithelial Mapping & Topography !!

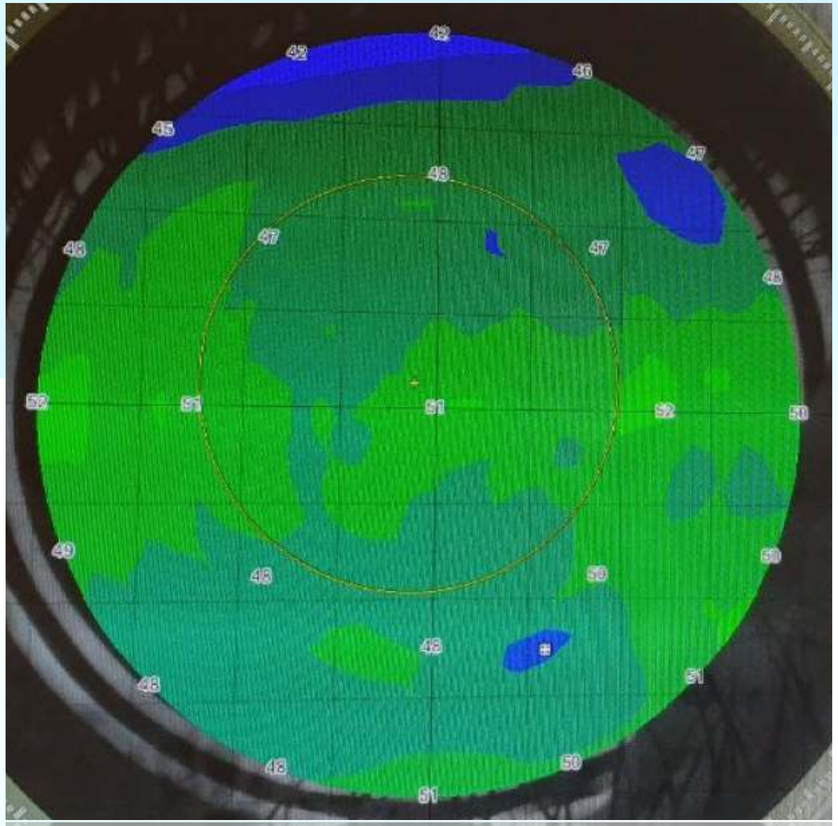
EM has been really changed the map



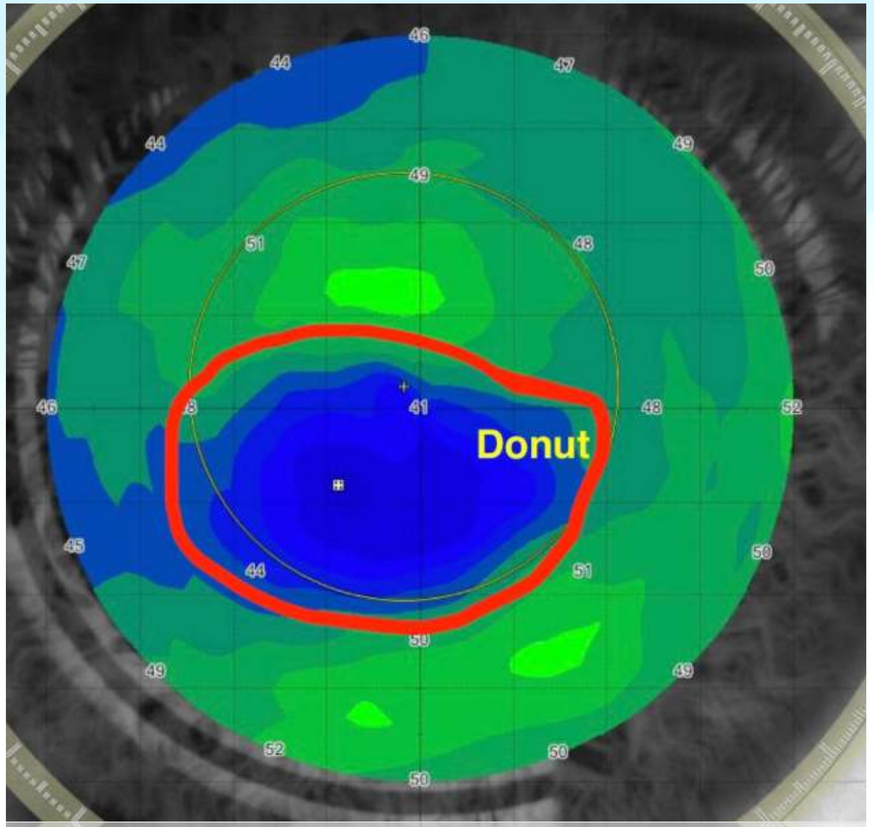
- It explains unexplained irregular surface.
- Helps differentiate significant & insignif. surface steep points.
- Excludes or Confirms what u do think it's abnormal.
- Detects topographical KC changes much earlier than before !!!



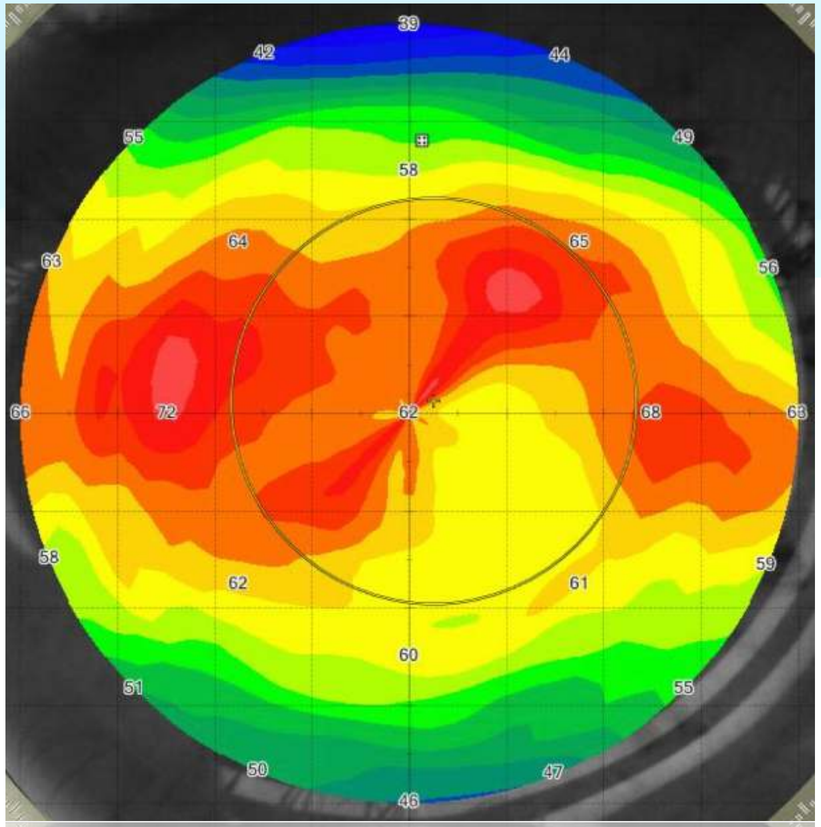
Normal Epith map



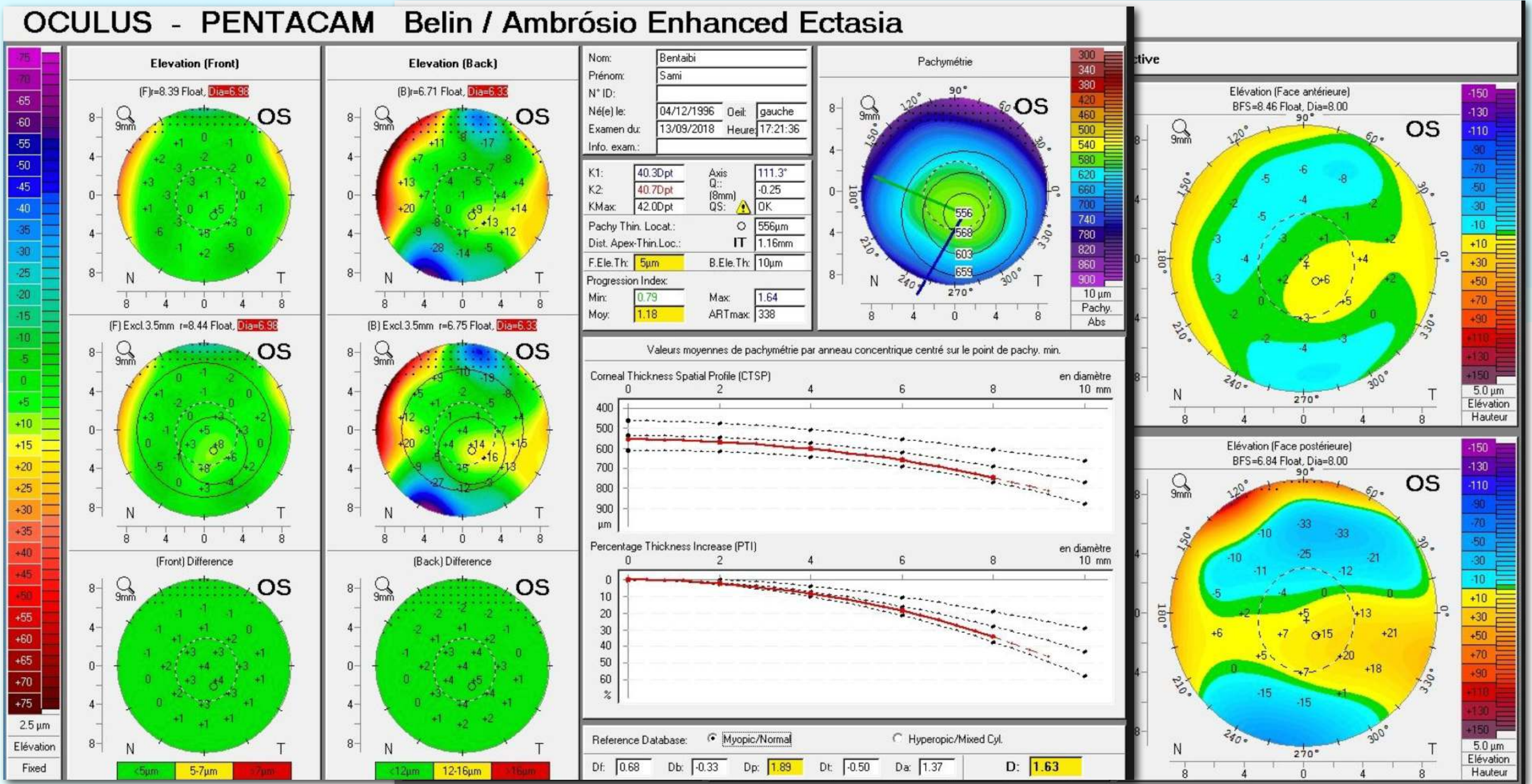
Epith thinning (Donut sign)



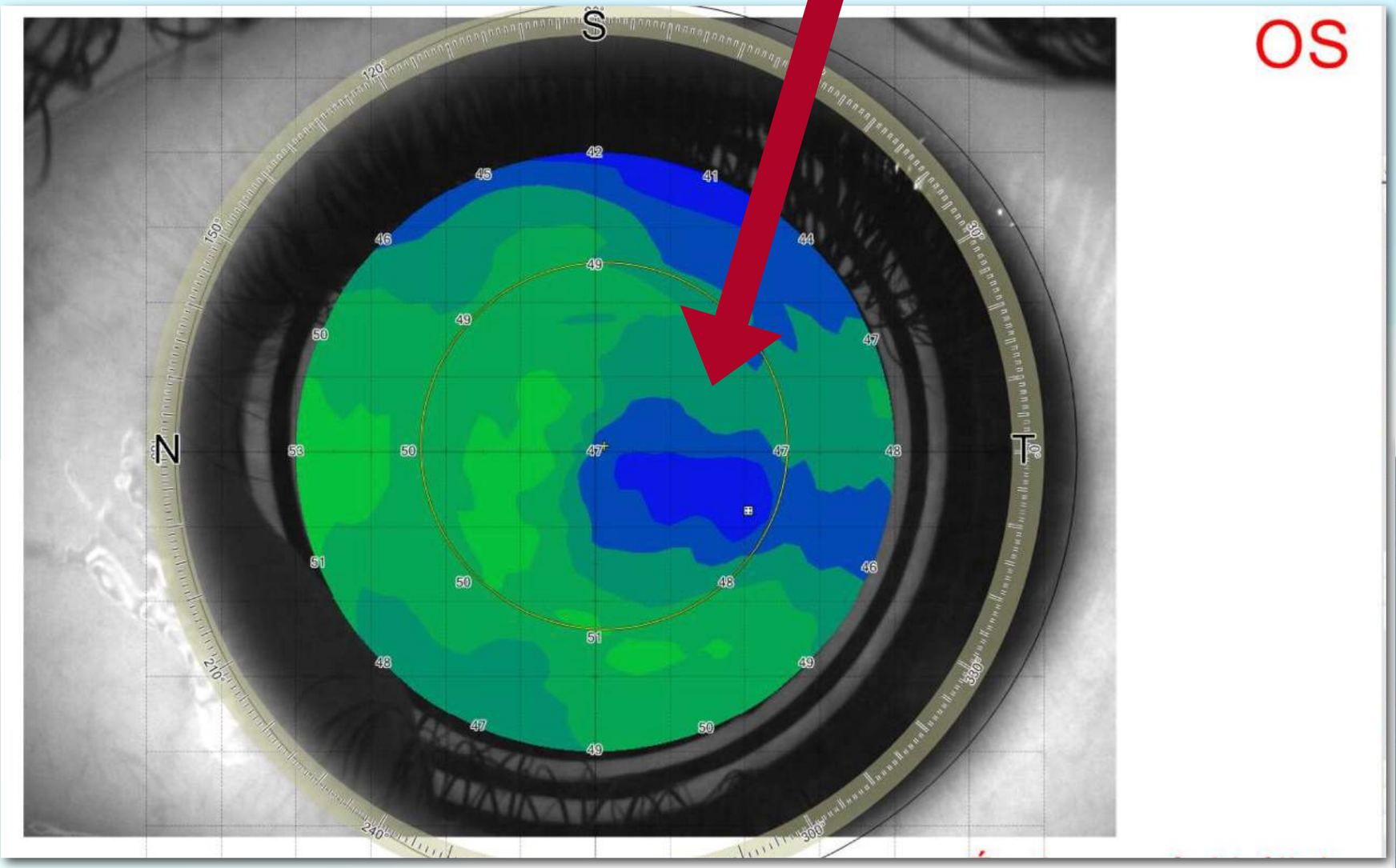
Epith thickening = assuring sign

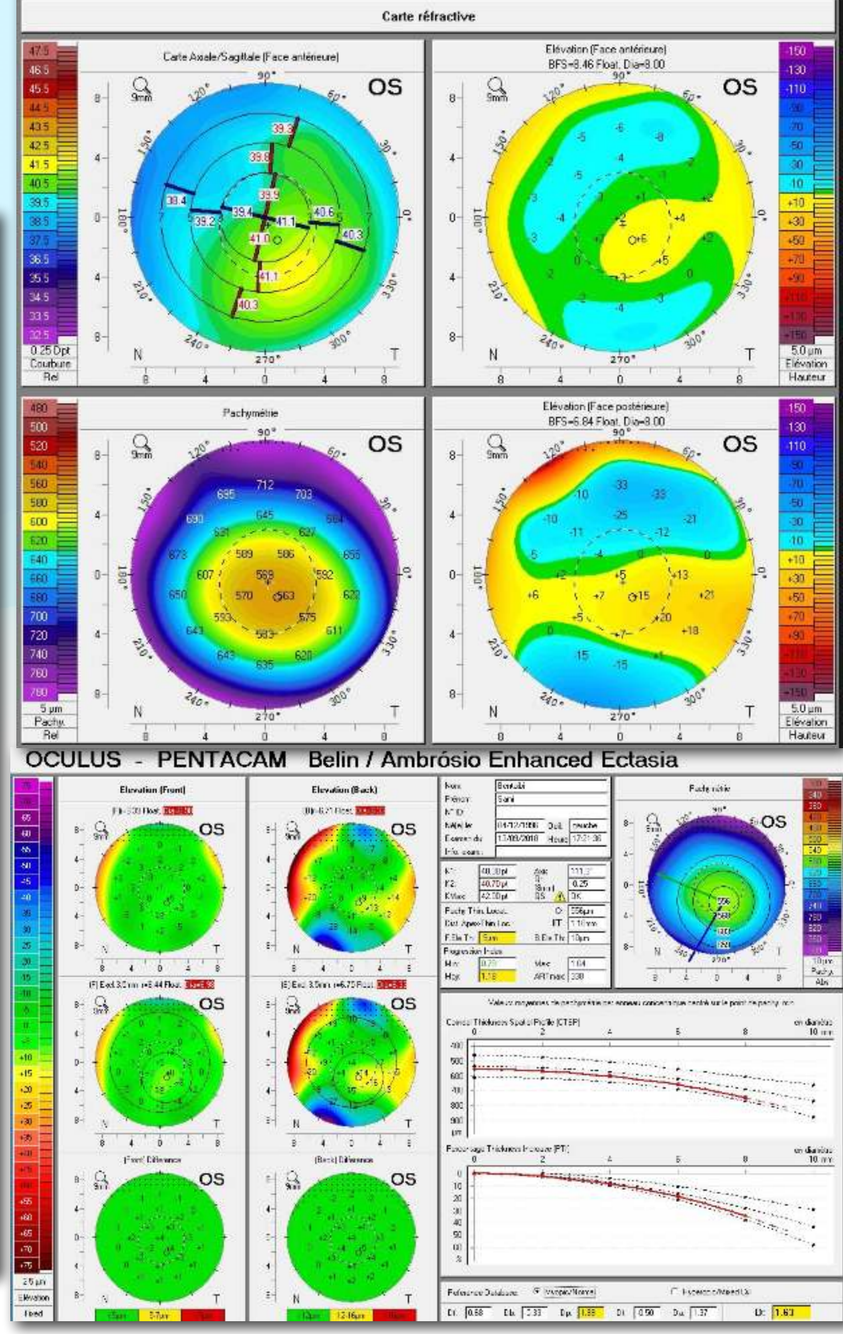


Example !!


OCULUS - PENTACAM Belin / Ambrósio Enhanced Ectasia
Elevation (Front)
(F)r=8.39 Float, Dia=6.98
Elevation (Back)
(B)r=6.71 Float, Dia=6.33
(F) Excl.3.5mm r=8.44 Float, Dia=6.98
(B) Excl.3.5mm r=6.75 Float, Dia=6.33
(Front) Difference
(Back) Difference
<5µm
5-7µm
>7µm
<12µm
12-16µm
>16µm
Nom: Bentaibi
Prénom: Sami
N° ID:
Né(e) le: 04/12/1996 Oeil: gauche
Examen du: 13/09/2018 Heure: 17:21:36
Info. exam.:
K1: 40.3Dpt Axis 111.3°
K2: 40.7Dpt Q:: (8mm) -0.25
KMax: 42.0Dpt QS: OK
Pachy Thin. Locat.: 556µm
Dist. Apex-Thin.Loc.: IT 1.16mm
F.Ele.Th: 5µm B.Ele.Th: 10µm
Progression Index:
Min: 0.79 Max: 1.64
Moy: 1.18 ARTmax: 338
Pachymétrie
556
568
603
659
10 µm
Pachy.
Abs
Valeurs moyennes de pachymétrie par anneau concentrique centré sur le point de pachy. min.
Corneal Thickness Spatial Profile (CTSP)
en diamètre 10 mm
Percentage Thickness Increase (PTI)
Reference Database: Myopic/Normal Hyperopic/Mixed Cyl.
Df: 0.68 Db: -0.33 Dp: 1.89 Dt: -0.50 Da: 1.37 D: 1.63
Elévation (Face antérieure)
BFS=8.46 Float, Dia=8.00
Elévation (Face postérieure)
BFS=6.84 Float, Dia=8.00
5.0 µm
Elévation
Hauteur
2.5 µm
Elévation
Fixed

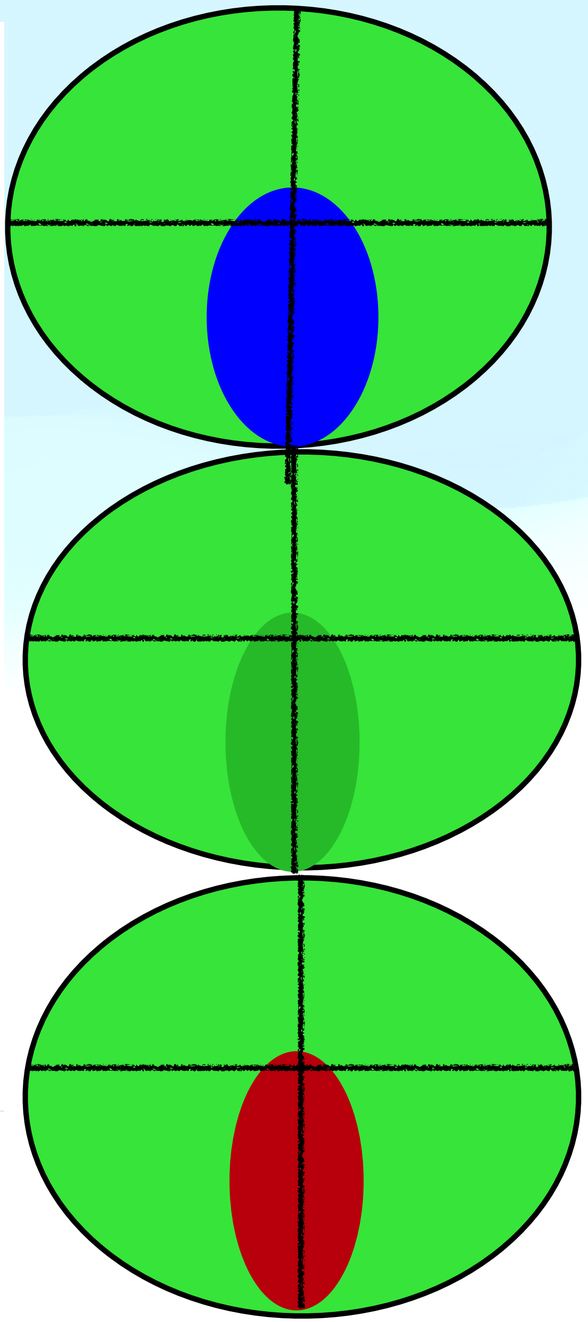
SURE DIAGNOSIS OF KC !!



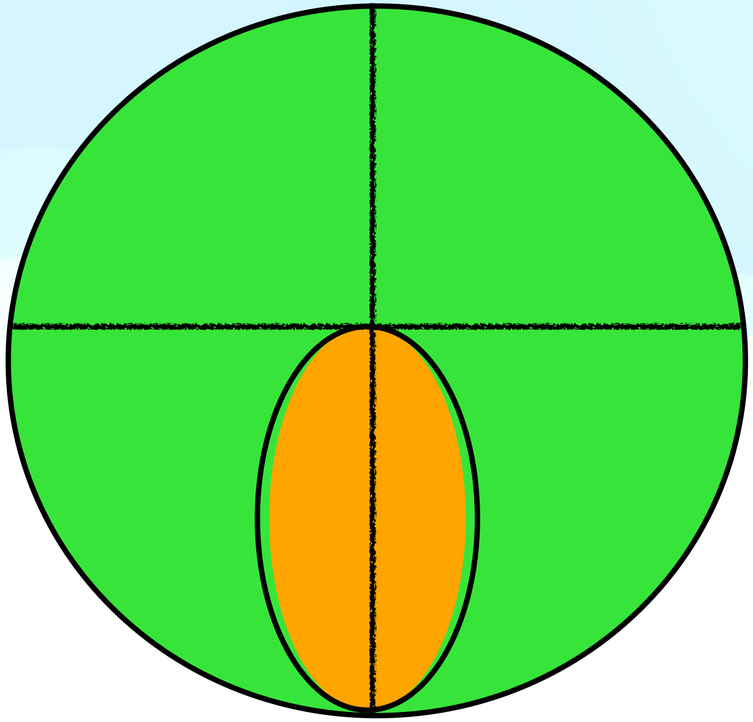


THE ROAD MAP

Epithelial map



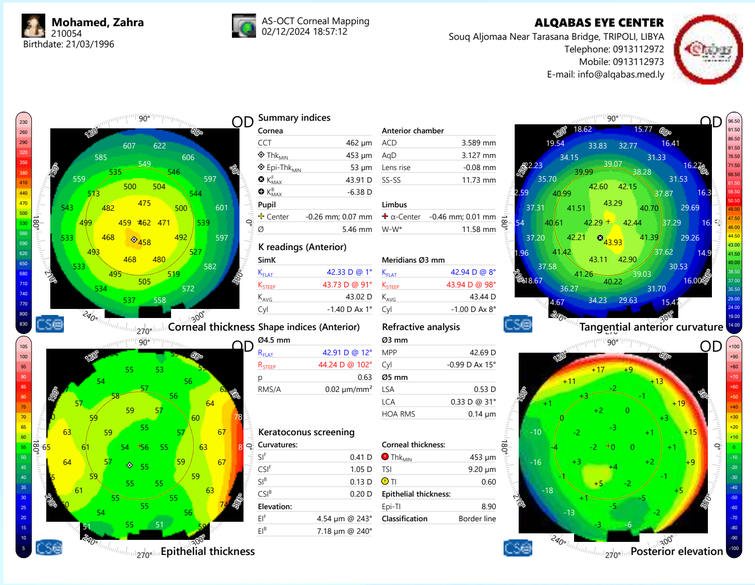
Topography



Role of Epithlial Thickness Mapping In Detection of Keratectasia

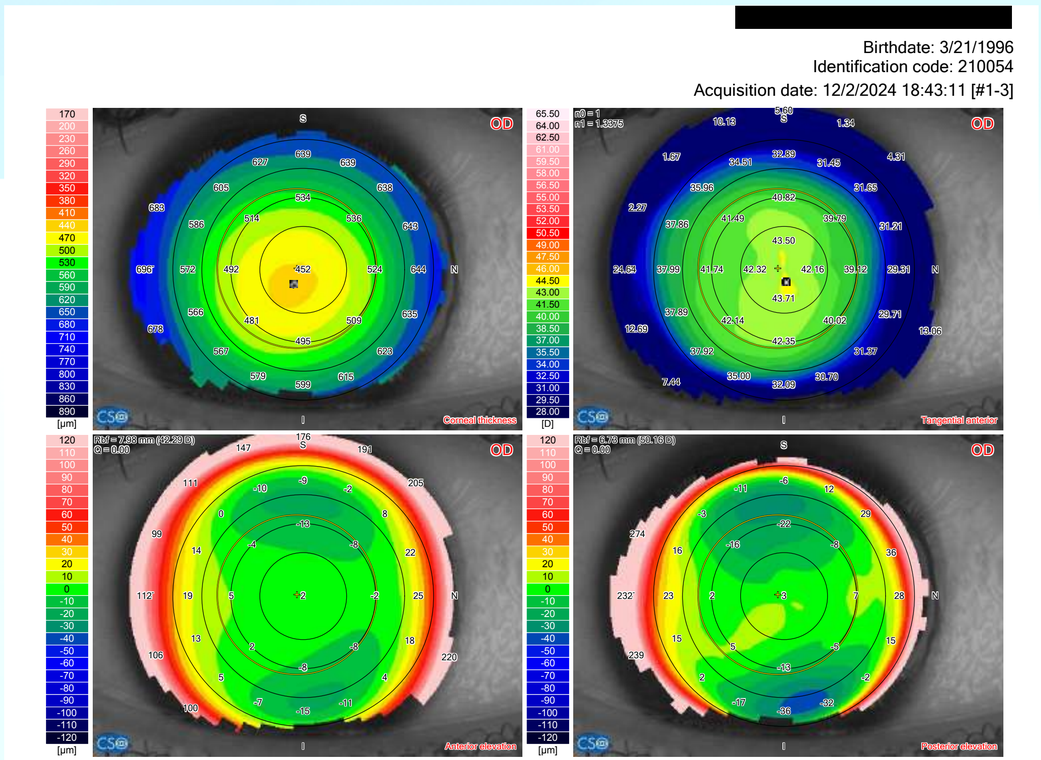
Facts, Trials, and value…

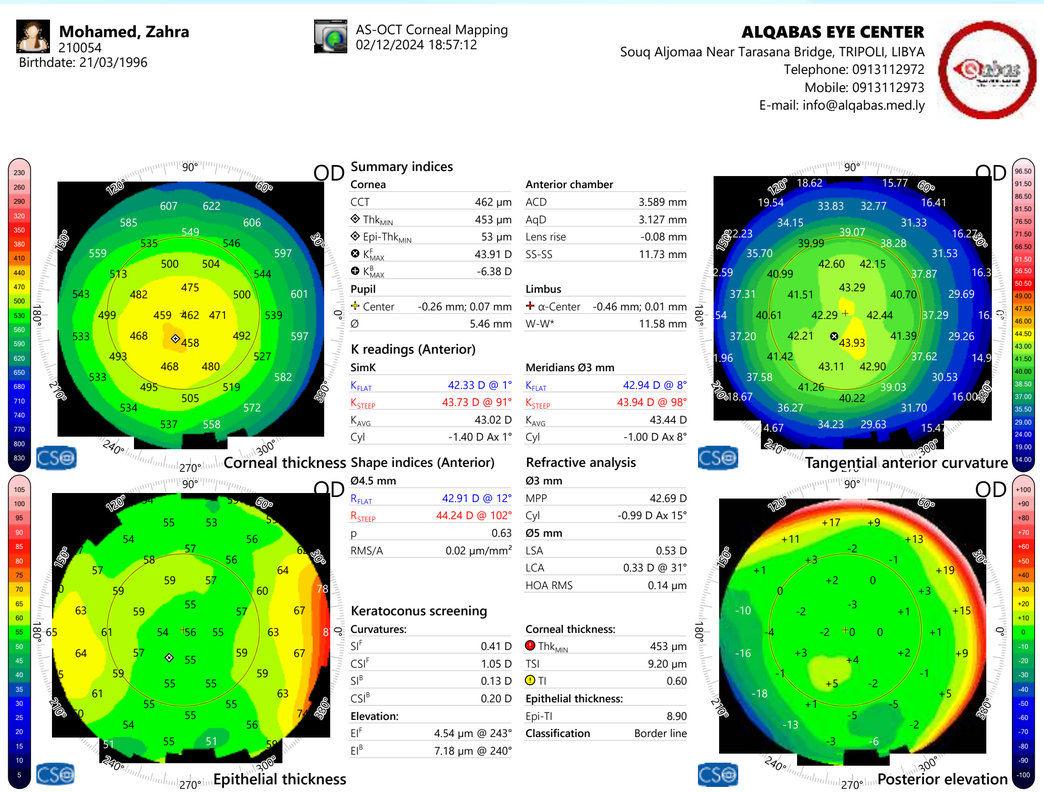
Facts:



- Detection of SBKC is challenging, as any single diagnostic tool or single parameter alone is not sufficient to detect early changes effectively.
- Corneal Topo & Tomography are considered the Golden standard in diagnosis of ectasia and in refractive surgery screening.

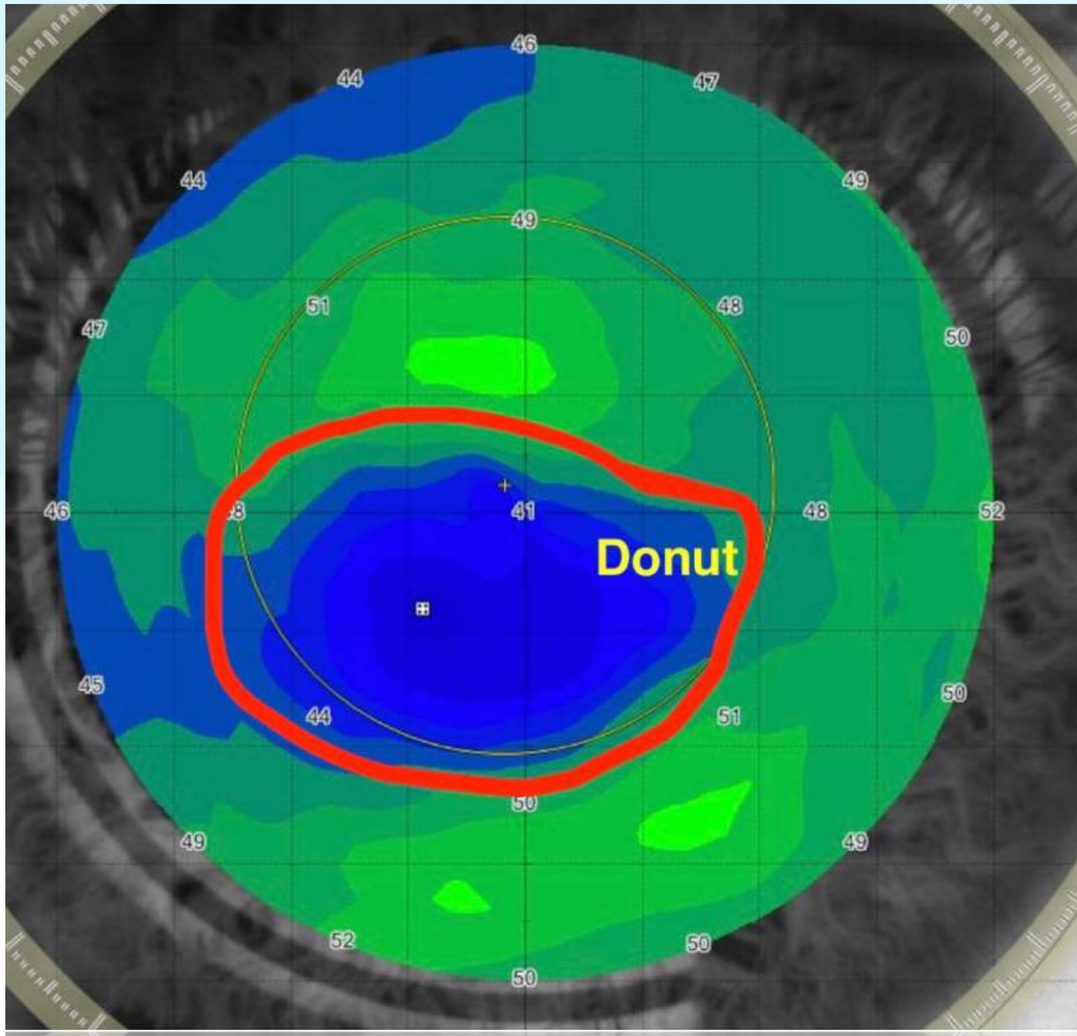
- Although, topographers are good at diagnosing KC, the sensitivity and specificity of most of its parameters in diagnosing SBKC or FFKC are poor.





- In ETM, a significant reduction of epith. thickness in KC has been reported by many literatures, and recently, the role of ETM as an adjunct tool in detecting SBKC has been described.
- However, there is limited knowledge about utility of ETM in diagnosis of early KC (SBKC & FFKC).

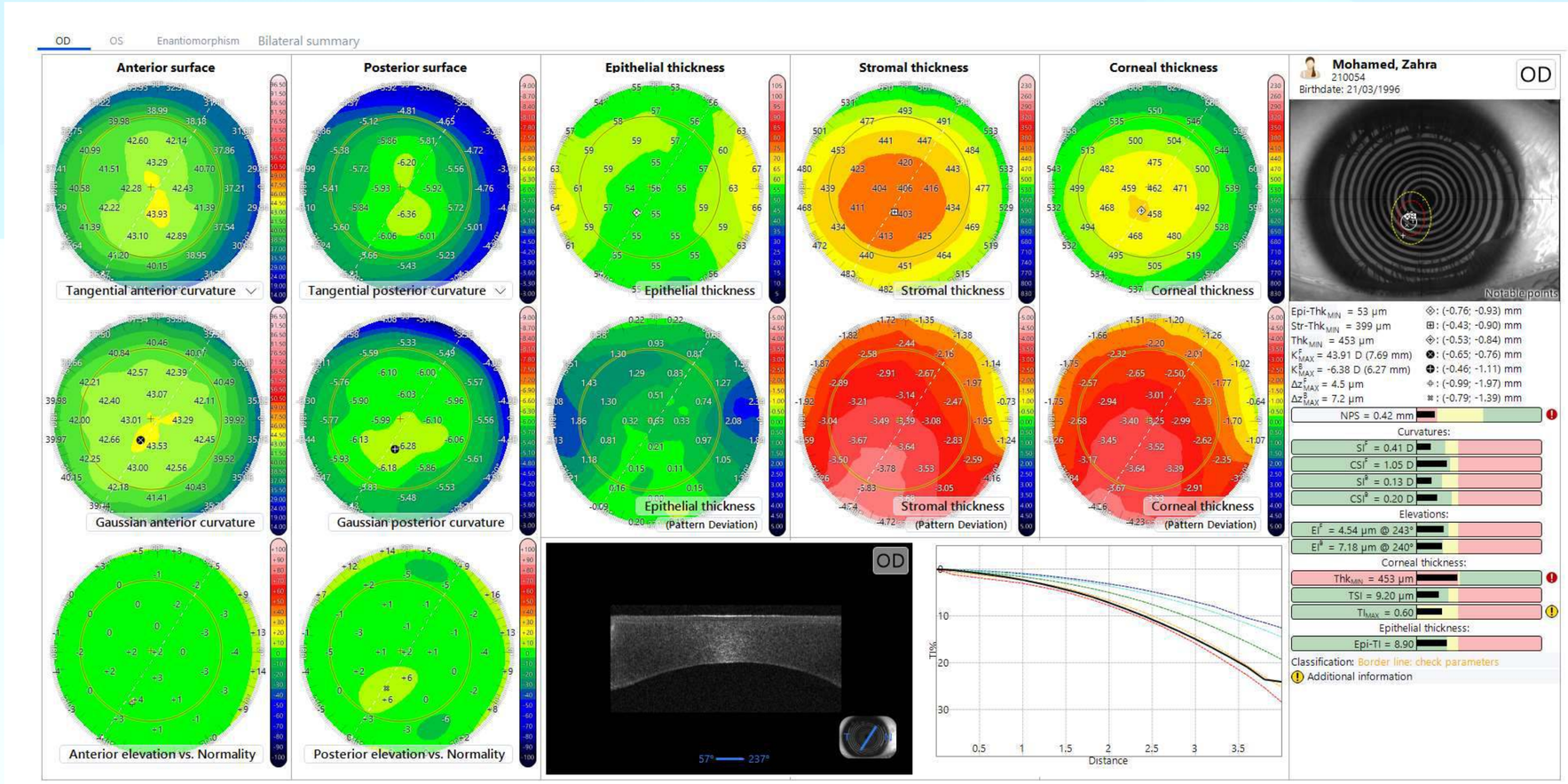
- But it seems that **ETM** has a great value in detection of of early ectasia, especially those with changes on the Back Surface Parameters.The hallmark is Donut sign formationn (Island of thinning surrounded wit a border of thickening)



Recent Researches = have a different opinion !!

- Vishal et al (2023) have studied 45 eyes with KC, 10 eyes with SBKC, and 10 eyes with FFKC, ETM was done using the MS 39 AS-OCT (CSO inc. Italy), and biomechanical properties testing using the Corvis st (Oculus inc. Germany) were done.
- They have concluded that the utility of epithelial mapping as a solitary tool is highly sensitive in detecting the established KC.
- But it may be of limited value in detection of SB and FFKC if used as a single tool. However, combining it with corneal biomechanical parameters could help improve the efficacy of diagnosis of the very early KC.

- However, Wyatt et al (2023) have reviewed the combined utilization of epithelial thickness mapping and tomography in screening of patients going for refractive surgery and found a differently an important role for ETM in detection of ectasia.

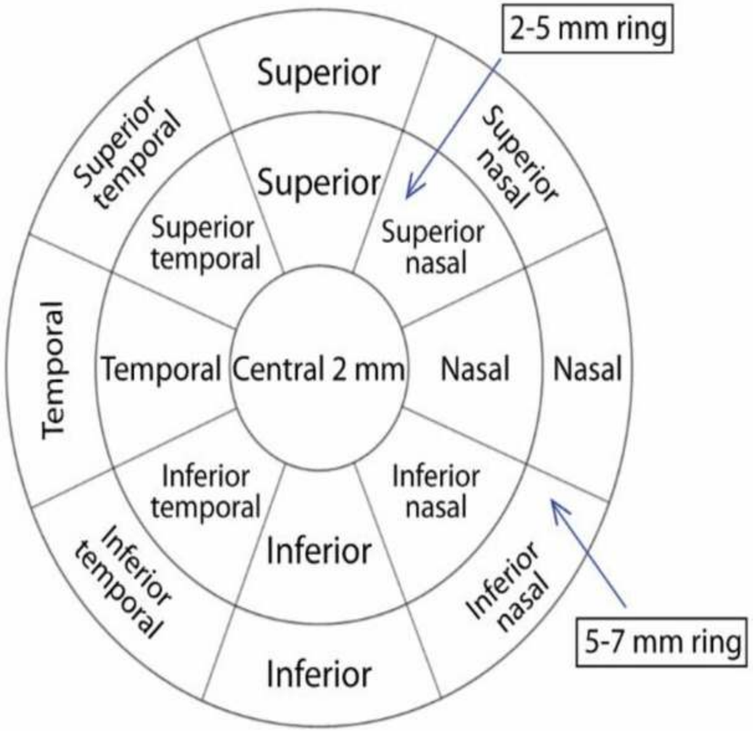


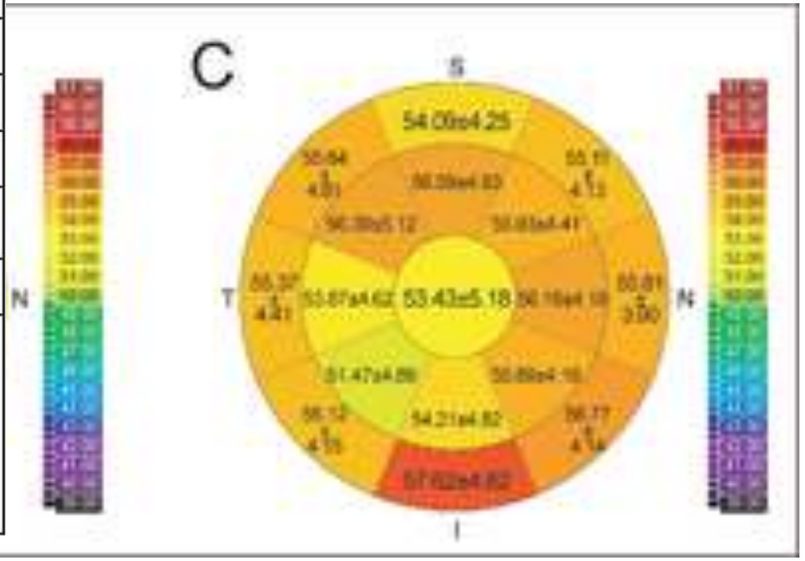
How to measure ETM?

Table A
Technical Specifications of the Three Devices for ETM

Parameter	MS-39	Anterion	Avanti
Light source wavelength (nm)	OCT: 845 Placido: 635	1300	840
A-scan speed	102,400	50000	70000
Axial resolution (μm)	3.6	<10	5
Transverse resolution (μm)	35	<45	15
A-scan depth (mm)	7.5	14	3
Maximum Scan width (mm)	16	16.5	12
B scan	10 × 5[a]	65 × 1	8 × 5
Number of A-scans per B-scan	1024[b]	256	1024
Acquisition time (s)	1	0.33	0.58

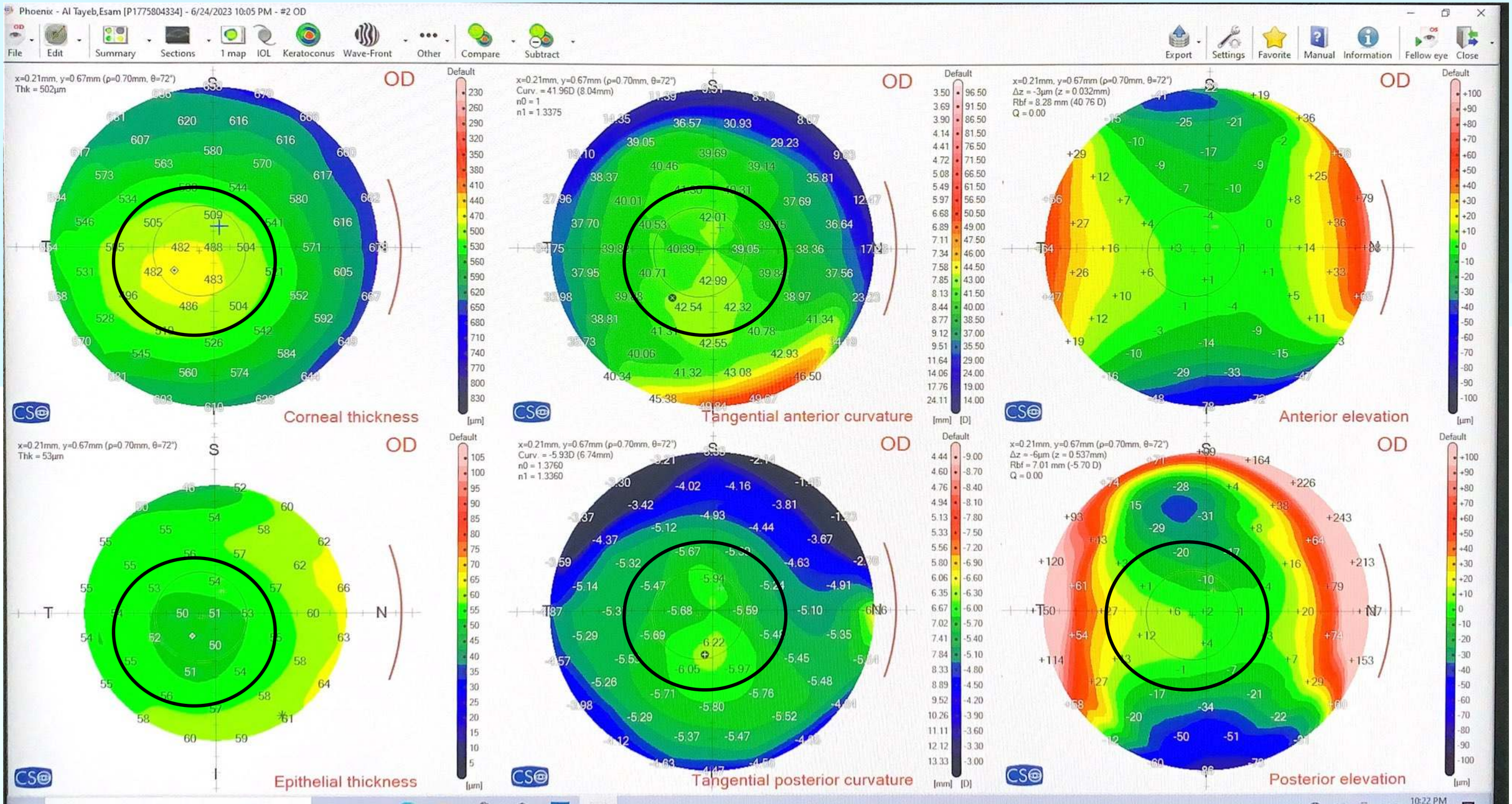
ETM = epithelial thickness mapping; OCT = optical coherence tomography
[a]*Customized in this study as recommended by the manufacturer.*
[b]*1600 A-scan on 16 mm and 800 A-scan on 8 mm.*





Clinical Cases From Daily Practice

EXAMPLE: EPITH MAP DOES A GREAT JOB !!

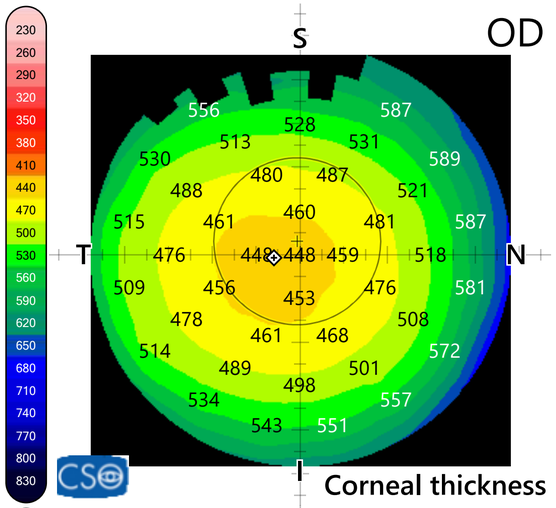


Salah Eid, Ibrahim
P0129701159
Birthdate: 5/10/2001

AS-OCT Corneal Mapping
5/16/2024 9:04 PM:04

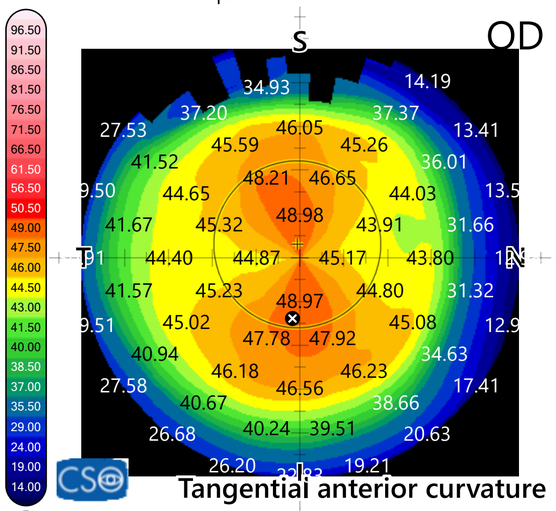
Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Telephone: 02 26 7000 84
Mobile: 01201622200

SimK
K_{FLAT} = 45.05 D @ 7°
K_{STEEP} = 49.04 D @ 97°
K_{AVG} = 46.96 D
Cyl = -3.99 D Ax 7°

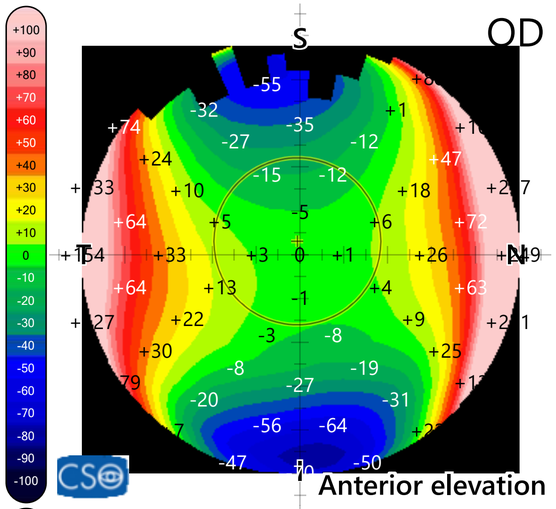


Corneal thickness

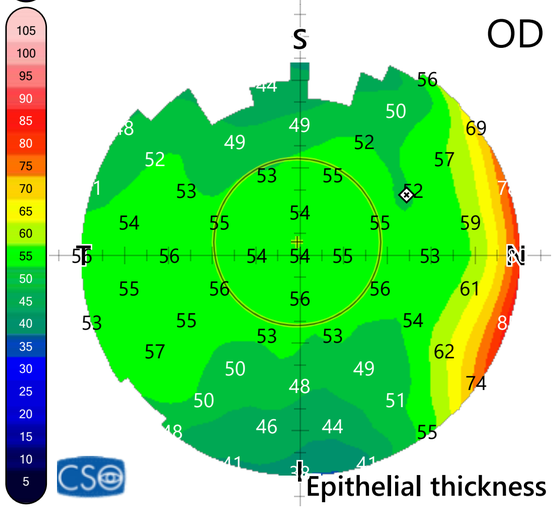
K^{F}_{MAX} = 47.59 D (7.09 mm)
Thk_{MIN} = 445 µm
Epi-Thk_{MIN} = 52 µm
W-W* = 11.61 mm
CCT + AqD = 0.448 + 3.388 = 3.836 mm



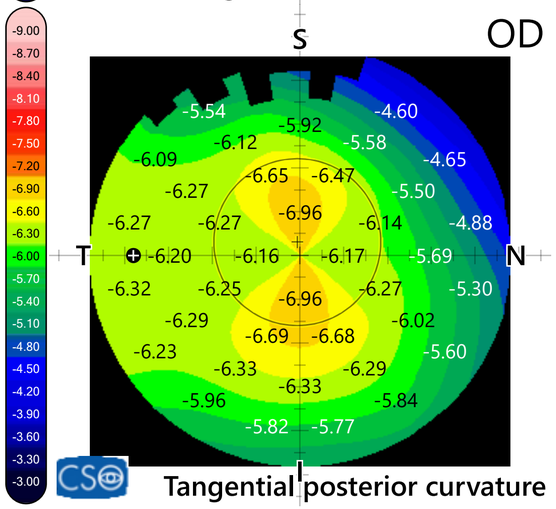
Tangential anterior curvature



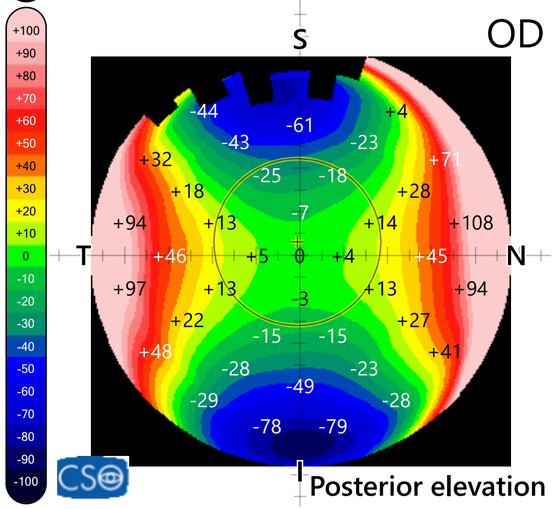
Anterior elevation



Epithelial thickness

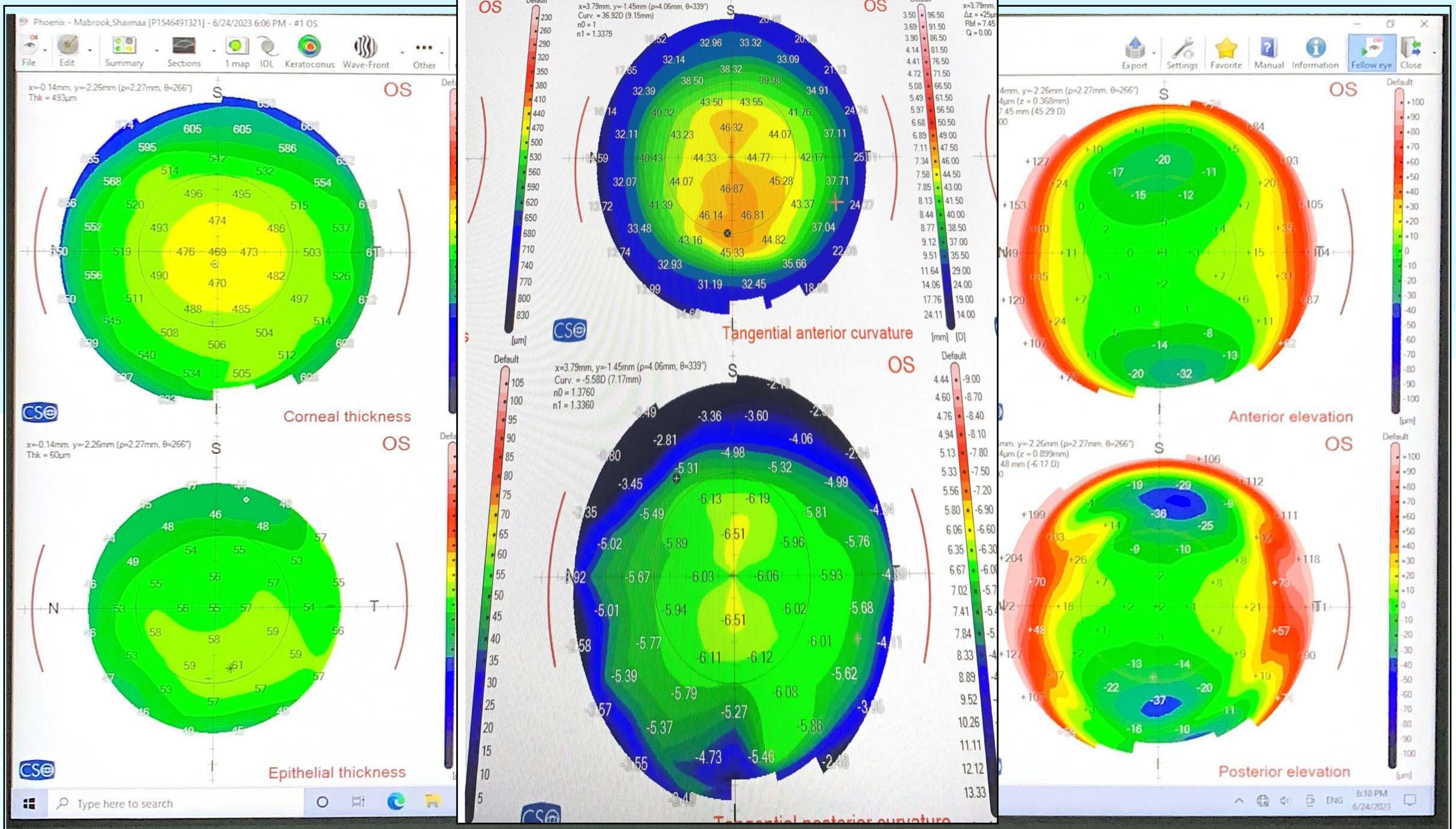


Tangential posterior curvature

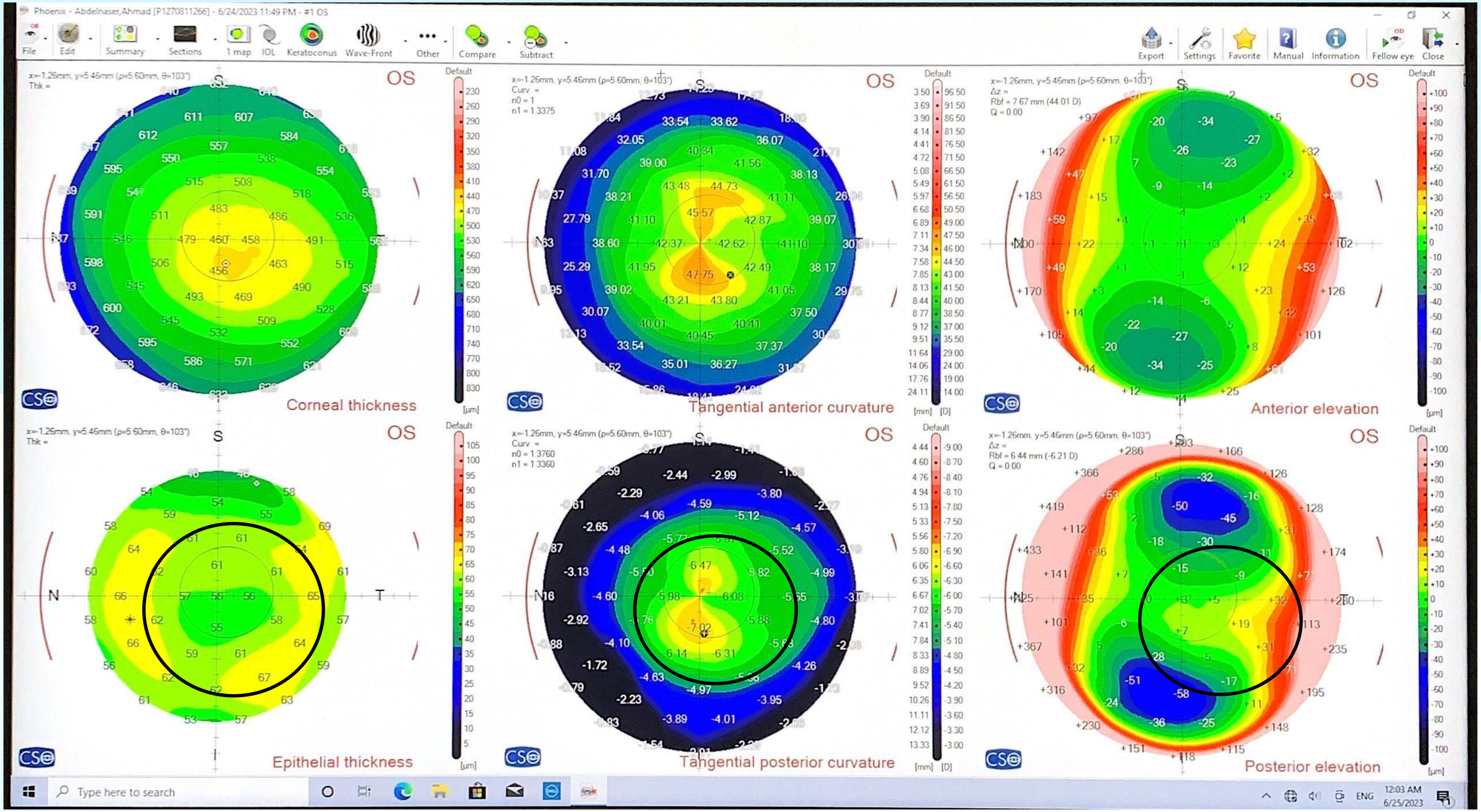


Posterior elevation

👀👀 DO U SUSPECT ?


Phoenix - Mabrook,Shaimaa [P1546491321] - 6/24/2023 6:06 PM - #1 OS
File
Edit
Summary
Sections
1 map
IOL
Keratoconus
Wave-Front
Other
OS
Corneal thickness
Epithelial thickness
Compare
Subtract
Tangential anterior curvature
Export
Settings
Favorite
Manual
Information
Fellow eye
Close
Anterior elevation
Posterior elevation
Type here to search

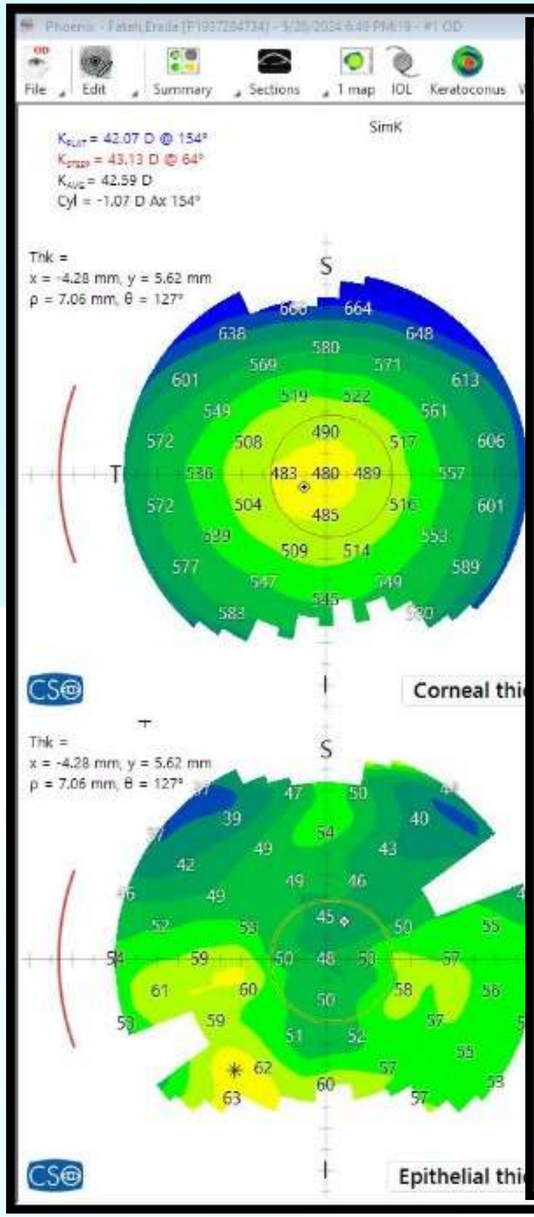
👀👀 DO U SUSPECT ? EPITH MAP CONFIRMS THE SUSPECION !!

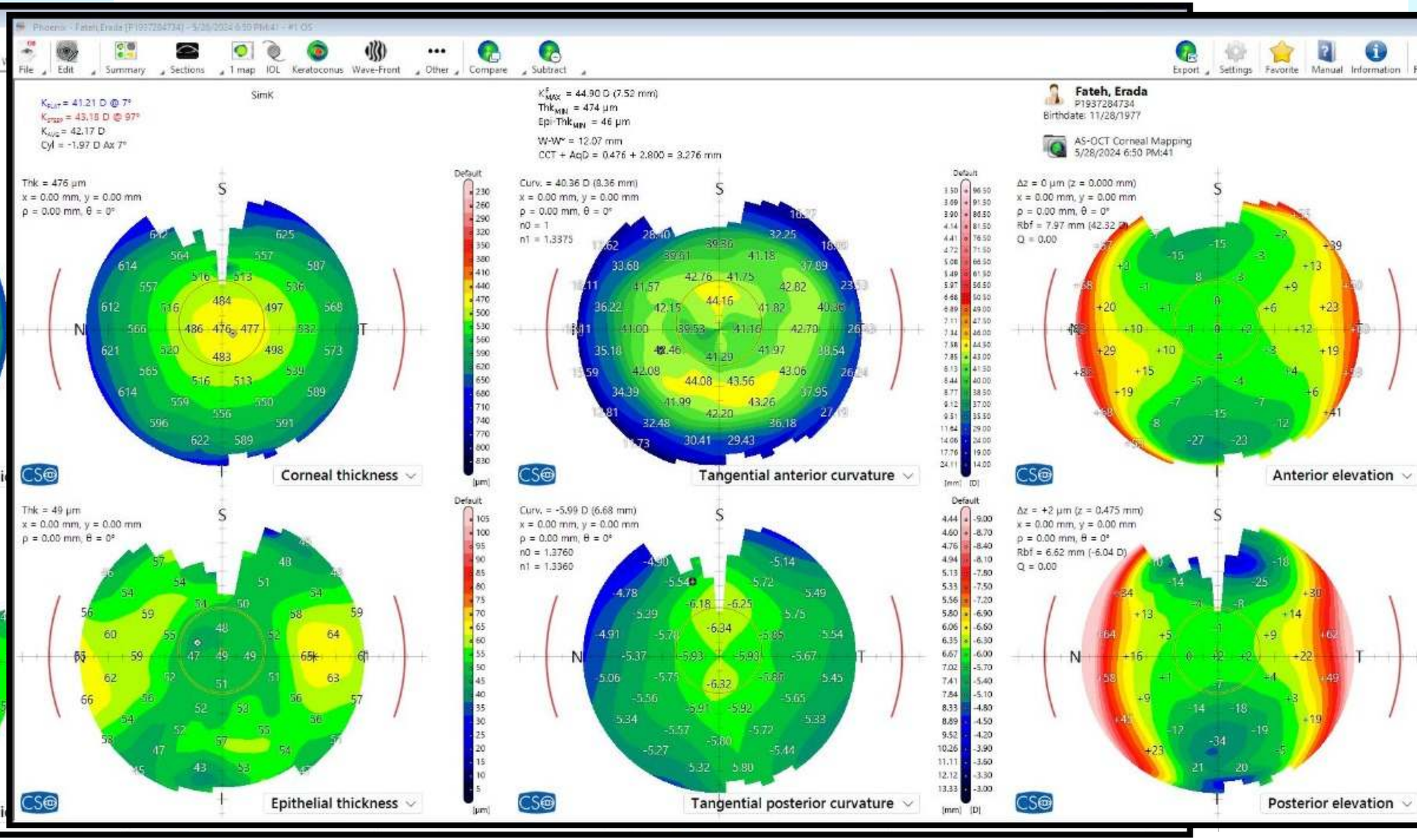


Irregular Epith. With normal cornea

AS-OCT Corneal Mapping
6/2/2024 5:44 PM:45

Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Telephone: 02 26 7000 84
Mobile: 01201622200





What do u think ??

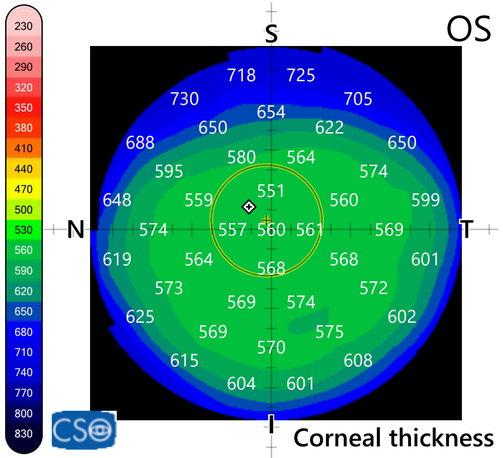
[redacted]

Birthdate: 11/3/1982

AS-OCT Corneal Mapping
2/11/2025 1:25 PM:19

Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Telephone: 02 26 7000 84
Mobile: 01201622200

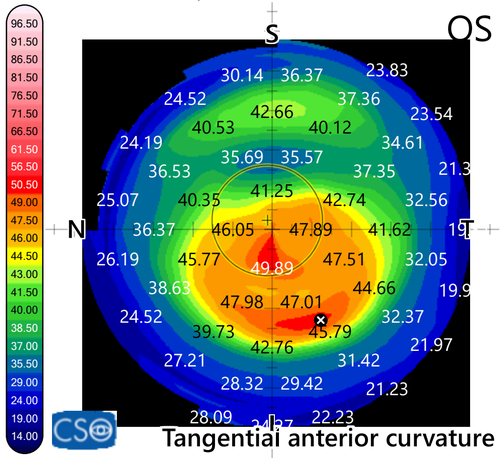
SimK
K_{FLAT} = 45.04 D @ 108°
K_{STEEP} = 47.26 D @ 18°
K_{AVG} = 46.12 D
Cyl = -2.22 D Ax 108°



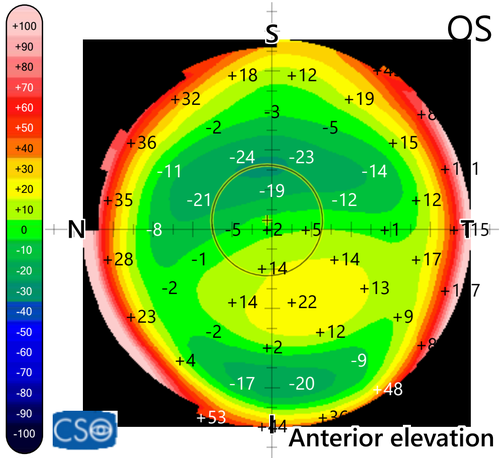
Corneal thickness

K^{F}_{MAX} = 50.33 D (6.71 mm)
Thk_{MIN} = 551 µm
Epi-Thk_{MIN} = 40 µm

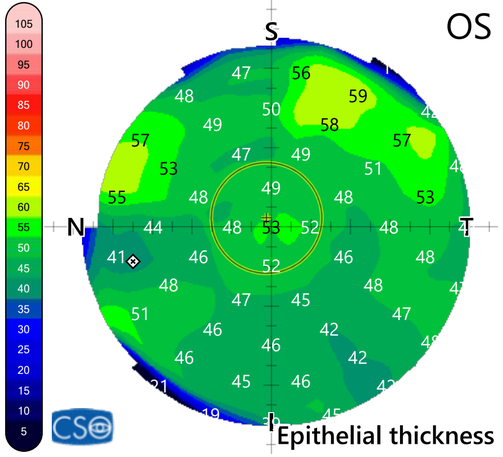
W-W* = 11.24 mm
CCT + AqD = 0.560 + 3.075 = 3.635 mm



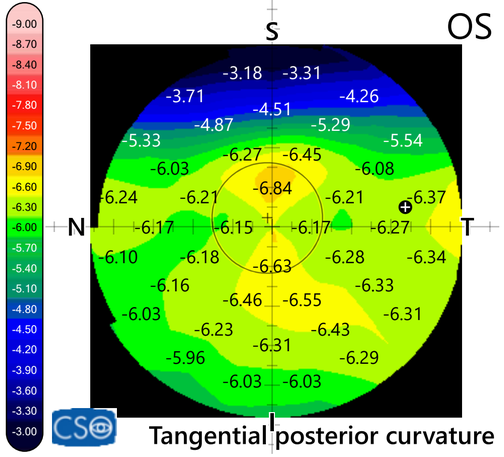
Tangential anterior curvature



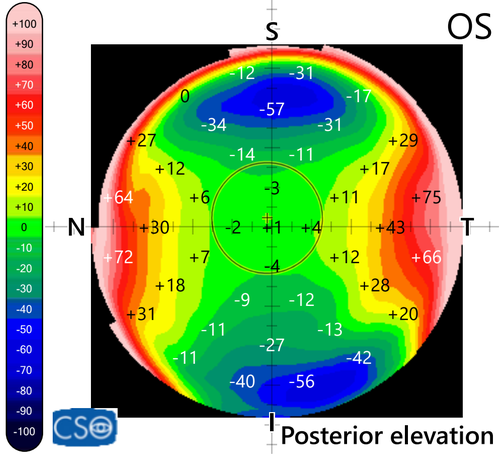
Anterior elevation



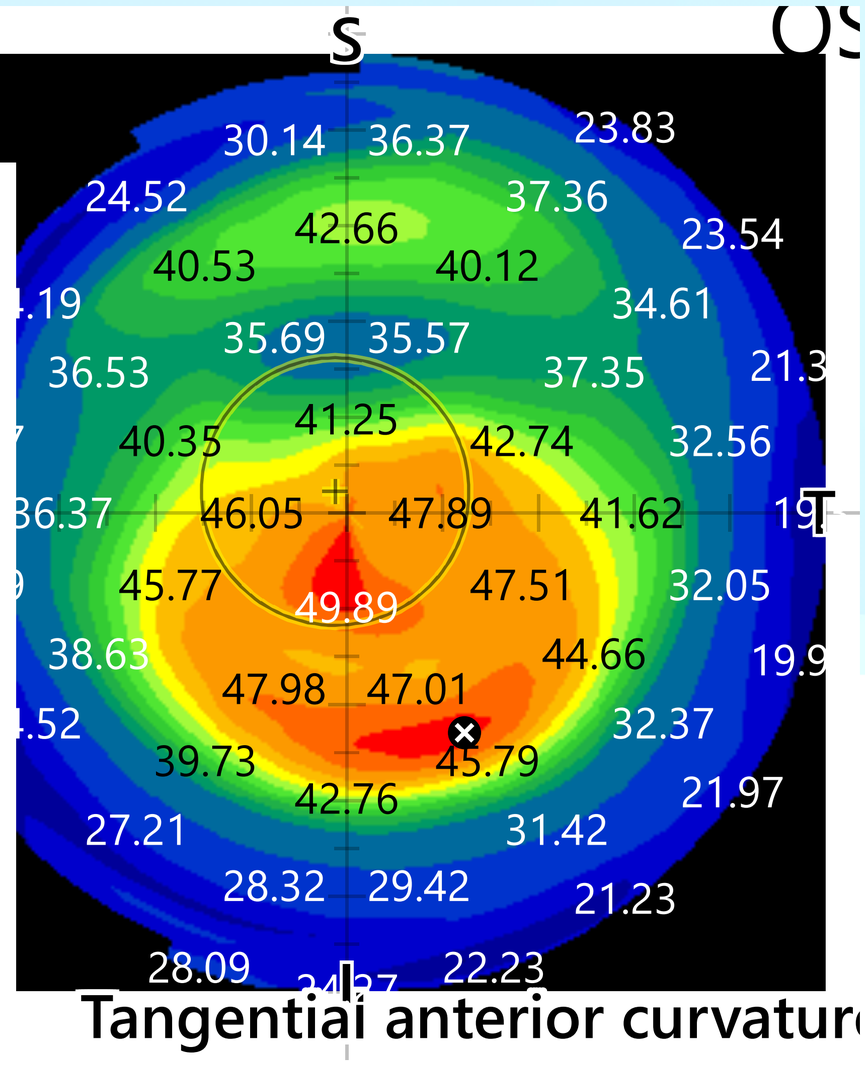
Epithelial thickness



Tangential posterior curvature



Posterior elevation



Tangential anterior curvature

Contact lens Wrpage !!

[redacted]

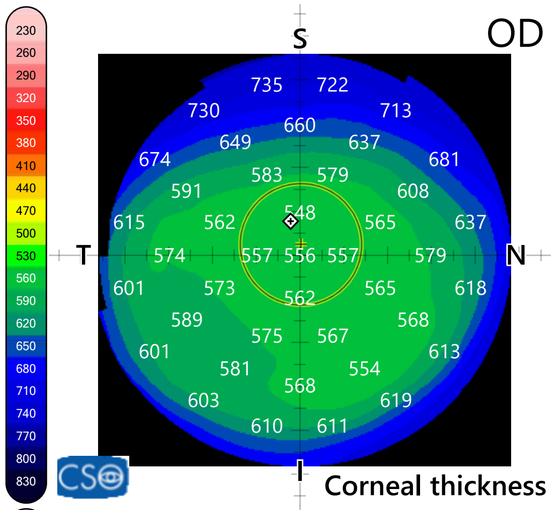
Birthdate: 11/3/1982

AS-OCT Corneal Mapping
2/11/2025 1:23 PM:43

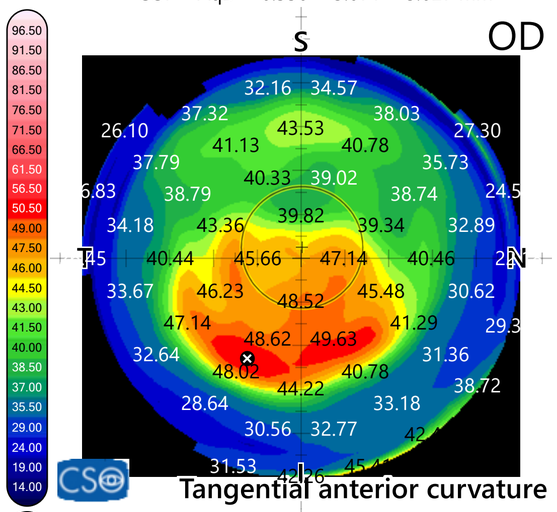
Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Telephone: 02 26 7000 84
Mobile: 01201622200

SimK
K_{FLAT} = 44.60 D @ 77°
K_{STEEP} = 46.34 D @ 167°
K_{AVG} = 45.46 D
Cyl = -1.74 D Ax 77°

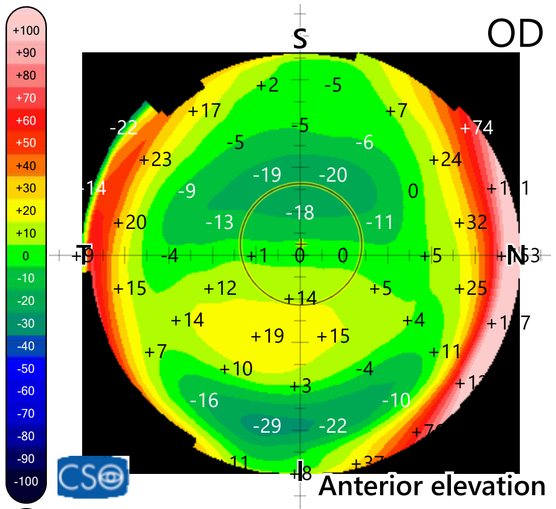
K^{F}_{MAX} = 49.81 D (6.78 mm)
Thk_{MIN} = 548 µm
Epi-Thk_{MIN} = 41 µm
W-W* = 11.38 mm
CCT + AqD = 0.556 + 3.071 = 3.627 mm



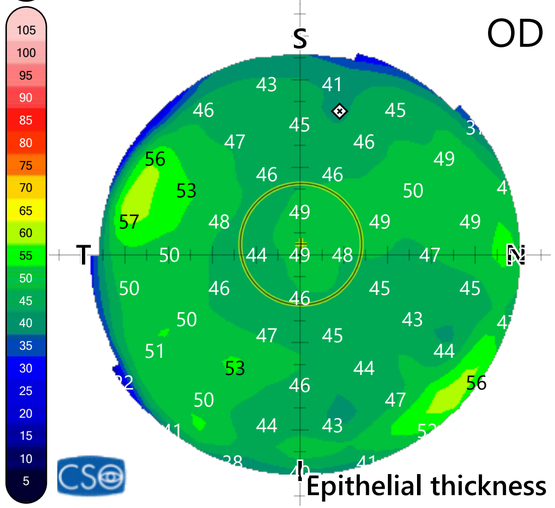
Corneal thickness



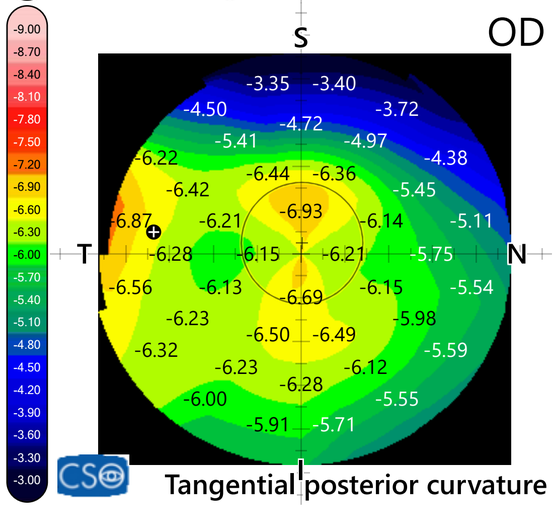
Tangential anterior curvature



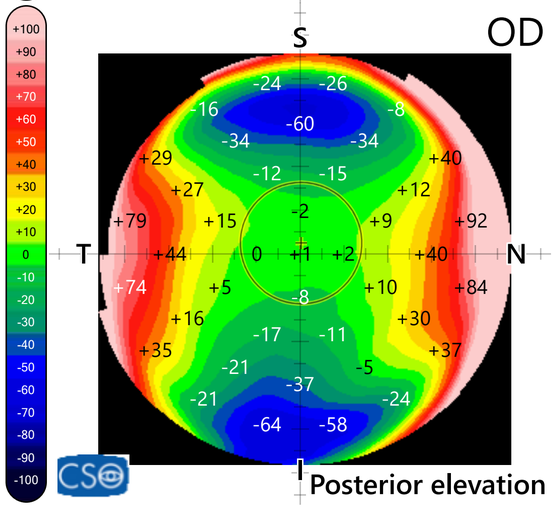
Anterior elevation



Epithelial thickness



Tangential posterior curvature



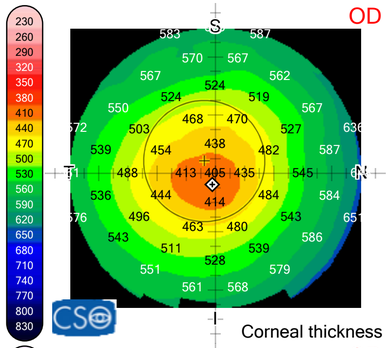
Posterior elevation

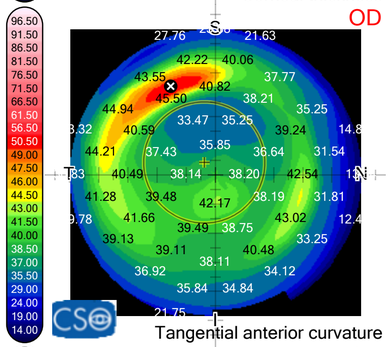
Post-LASIK !!!

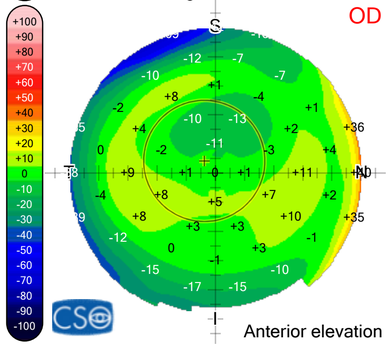
Mahmoud, Samer
P1951496132
Birthdate: 8/30/1998

AS-OCT Corneal Mapping
1/2/2024 2:29 PM

Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Mobile: 01201622200







Summary indices

Cornea	
Thk Min = 401 µm	: (-0.11; -0.39) mm
EpiThk Min = 46 µm	: (-1.77; -3.13) mm
EpiThk Max = 72 µm	: (0.92; -3.69) mm
StrThk Min = 345 µm	: (-0.11; -0.39) mm
K^F_{Max} = 47.79 D (7.06 mm)	: (-1.53; 3.04) mm
K^B_{Max} = -7.43 D (5.39 mm)	: (0.07; -0.60) mm
Gullstrand ratio = 1.41 (A/P) - 0.71 (P/A);	
Pupil (Topographic)	
Ø = 4.16 mm	: (-0.38; 0.42) mm
Anterior chamber	
CCT + AqD = 0.405 + 3.409 = 3.815 mm	
Lens rise = 0.06 mm	
SS-SS = 12.68 mm	
W-W* = 12.11 mm	: (-0.49; 0.02) mm
HACtilt = 8.1° T	

K readings / Shape indices

	Ø [mm]	Kf	Ks	Kavg	Cyl / Ax [D]/[°]
SimK	-	38.10	38.80	38.45	-0.71/160°
Meridians (Anterior)	3.00	38.32	39.70	39.00	-1.38/178°
	5.00	38.27	39.33	38.79	-1.06/174°
	7.00	38.39	39.01	38.70	-0.63/174°
Meridians (Posterior)	3.00	-6.31	-6.72	-6.51	0.41/0°
	5.00	-6.13	-6.44	-6.28	0.31/0°
	7.00	-5.94	-6.17	-6.05	0.24/0°
Shape indices (Anterior)	4.50	38.82	40.52	39.65	-1.69/176°
	Q = -1.06		RMS/A = 0.11 µm/mm² ⚠		
Shape indices (Posterior)	4.50	56.36	61.31	58.73	-4.96/6°
	Q = -3.03		RMS/A = 0.42 µm/mm² ⚠		

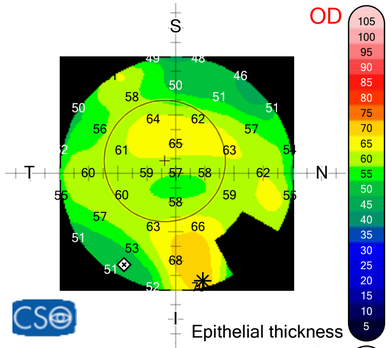
Refractive analysis

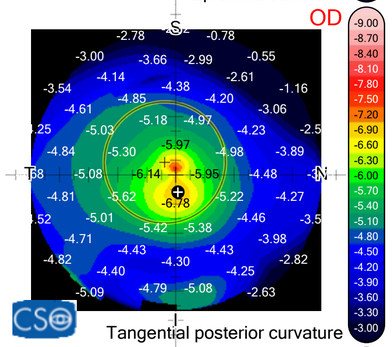
Ø = 3.00
MPP = 37.20 D
Cyl = -0.82 D Ax 157°
⚠LSA = -0.79 D
⚠LCA = 2.18 D @ 117°
⚠HOA RMS = 0.29 µm

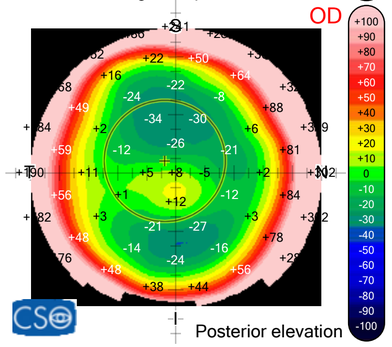
Ø = 5.00
MPP = 37.34 D
Cyl = -0.77 D Ax 141°
LSA = 0.41 D
⚠LCA = 3.30 D @ 78°
⚠HOA RMS = 0.87 µm

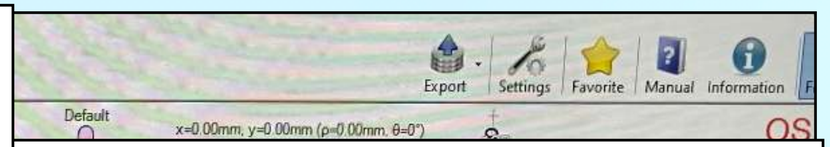
Keratoconus screening

Curvatures:	
⚠SI^F= 2.12 D	⚠SI^B= 0.57 D
CSI^F= 0.79 D	⚠CSI^B= 1.02 D
Elevation:	
⚠EI^F= 3.2 µm @ 104°	⚠EI^B= 4.8 µm @ 256°
Corneal thickness:	
⚠Thk_{Min} = 401 µm	
TSI = 12.67 µm	
⚠TI_{Max}= 7.01	
Classification	
Other	









rneal Mapping
29 PM

Ziada Eye Center
43 Makram Ebeid St., Cairo, Egypt
Mobile: 01201622200

dices

Cornea	
1 µm	: (0.60; 0.00) mm
43 µm	: (0.91; 3.28) mm
= 71 µm	: (2.55; -2.55) mm
391 µm	: (1.36; -0.34) mm
D (7.65 mm)	: (-1.08; -2.80) mm
D (6.55 mm)	: (0.12; -1.19) mm
tio = 1.24 (A/P) - 0.81 (P/A);	
Pupil (Topographic)	
	: (0.42; 0.28) mm
Anterior chamber	
= 0.462 + 3.336 = 3.798 mm	
.07 mm	
72 mm	
0 mm	: (0.74; 0.02) mm
° T	

Shape indices

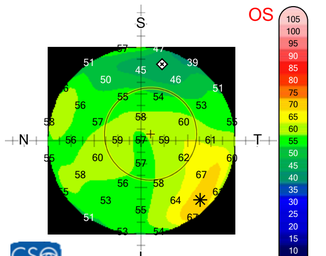
	Ø [mm]	Kf	Ks	Kavg	Cyl / Ax [D]/[°]
SimK	-	39.20	39.95	39.57	-0.75/154°
ridians	3.00	39.54	40.23	39.88	-0.70/165°
nterior)	5.00	39.42	40.13	39.77	-0.71/163°
	7.00	39.13	40.27	39.70	-1.14/161°
ridians	3.00	-5.67	-6.08	-5.87	0.42/150°
sterior)	5.00	-5.60	-6.02	-5.80	0.42/150°
	7.00	-5.52	-5.92	-5.71	0.41/164°
ndices	4.50	39.76	40.18	39.97	-0.42/140°
nterior)	Q = -0.24		RMS/A = 0.03 µm/mm²		
ndices	4.50	47.34	51.53	49.34	-4.20/156°
sterior)	Q = -0.53		RMS/A = 0.12 µm/mm² ⚠		

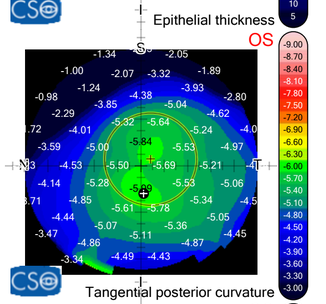
nalysis

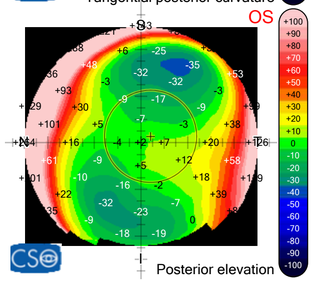
Ø = 3.00
D
Ax 79°
@ 216°
0.10 µm
Ø = 5.00
D
Ax 100°
@ 215°
0.26 µm

Keratoconus screening

Curvatures:	
SI^F= 0.71 D	⚠SI^B= 0.24 D
CSI^F= 0.03 D	CSI^B= 0.24 D
Elevation:	
EI^F= 0.0 µm @ 264°	⚠EI^B= 1.2 µm @ 302°
Corneal thickness:	
⚠Thk_{Min} = 451 µm	
TSI = 7.33 µm	
⚠TI_{Max}= 1.16	
Classification	
Myopic PostOp	







Conclusion

- In comparison with Topography alone, ETM profiles may improve the sensitivity and specificity of screening for early KC, which is helpful in clinical practice.
- As epithelial changes can be detected before any topographic changes of the cornea.
- ETM is a step to create epithelium-based diagnostic variables for early KC detection.

Conclusion

- Some authors stated that:
- The utility of ETM as a solitary tool is highly sensitive in detecting the established KC.
- But it may be of limited value in detection of SB and FFKC if used as a single tool. This is for now; could be changed later.
- However, combining ETM with Tomography, and / or corneal biomechanical parameters could help improve the efficacy of diagnosis of the very early KC.

Conclusion

- As a result, we can conclude that ETM has a great value in diagnosis of KC confirming the suspicious points on the Topo & Tomography maps, especially in patients of SBKC and FFKC.
- So that ETM is still of value in the ectasia screening and diagnosis, but it would be of greater value if combined with other new tools to be more sensitive and specific.
- Furthermore, other studies with wider scales are needed to confirm this consensus.

New innovations are coming, Keep updated !

Thank you