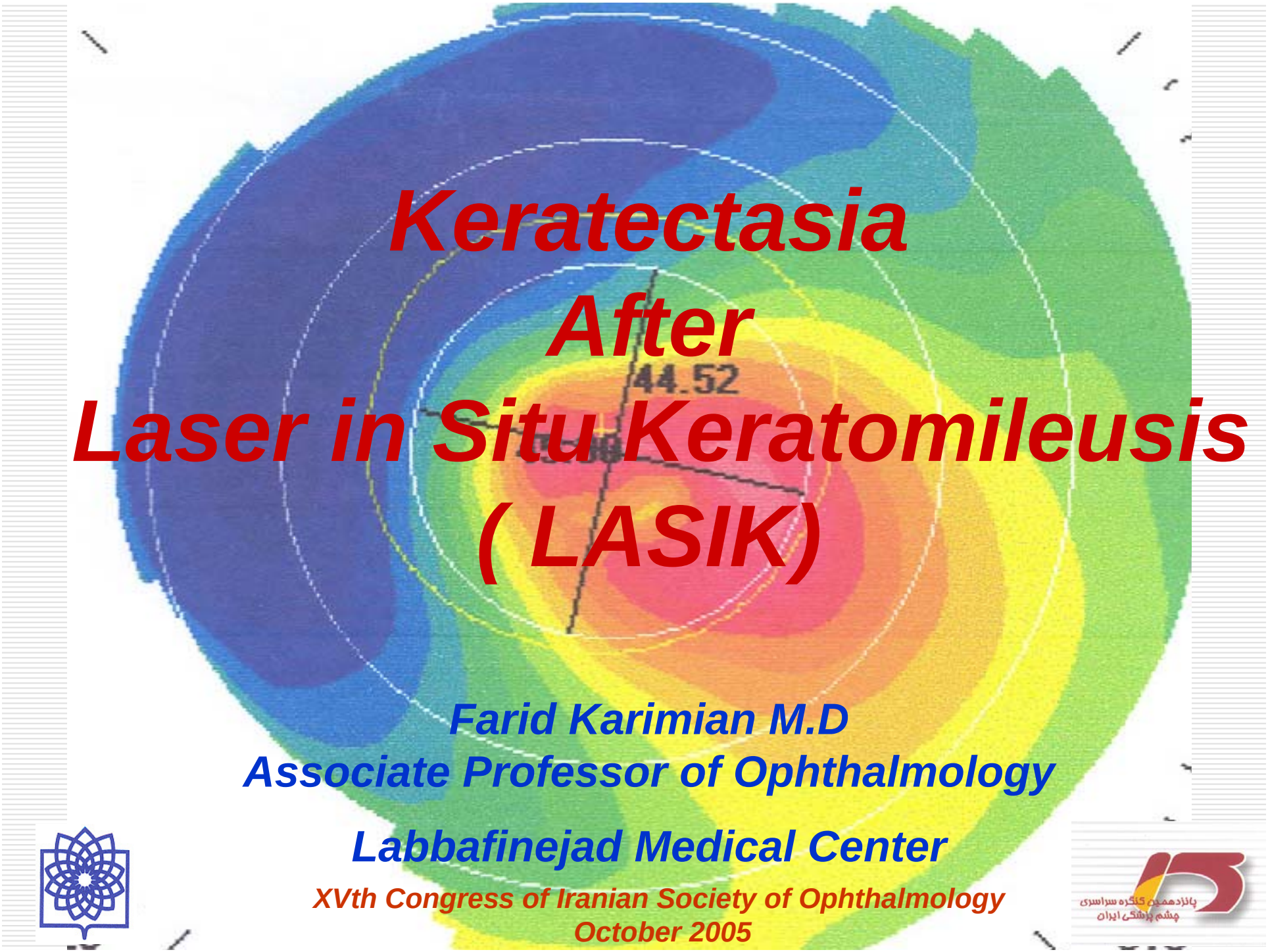

Keratectasia After Laser in Situ Keratomileusis (LASIK)

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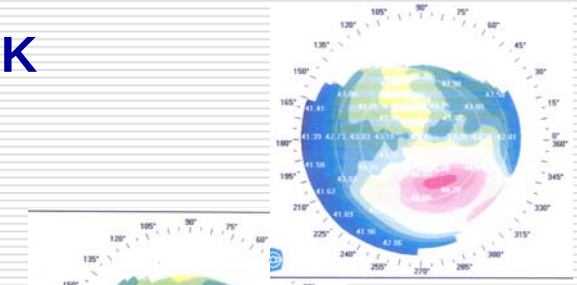
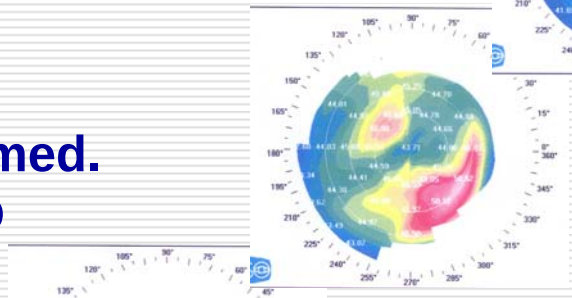
XVth Congress of Iranian Society of Ophthalmology
October 2005

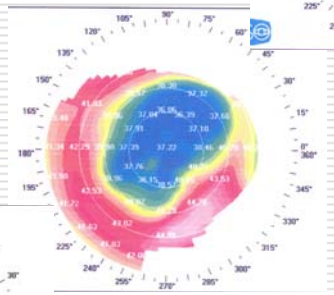
Case Presentation

- *May 2000:* **Mr. A.N. 34 Y/O employee had LASIK on his both eyes for -9.0 D Myopia**
  *** LASIK OD became complicated by "incomplete flap"**

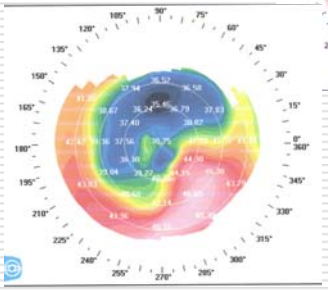


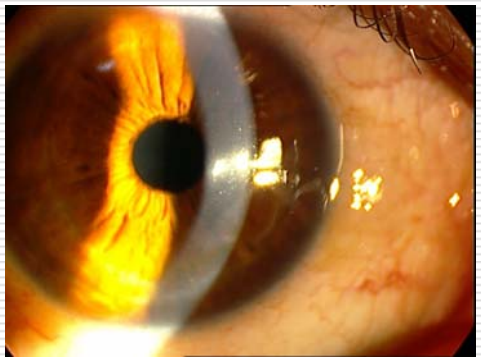
- *Nov. 2000:* **Re- LASIK OD was performed. Again after 6 mo enhancement OD to correct -2 D Residual Myopia.**





- *October 2005:* **Refraction OD is -7.00-4.00 x 95° with BCVA 20/120**





Background

- **Barraquer (1980) reported Keratectasia following Myopic Keratomileusis *Conclusion:* the Residual stromal thickness is important to prevent Ectasia**

- **Seiler (1998) reported first typical form of Post-LASIK Ectasia**

- **Keratectasia is also reported after:**

*** Keratophakia or Myopic Keratomileusis**
*** Hyperopic ALK (62%): " controlled ectasia"**
*** Radial keratotomy * Hexagonal Keratotomy**

- LASIK , PRK (1)

(1) Holland SP, Srivannaboons, Reinstein DZ: Ophthalmology 2000:18:177-184

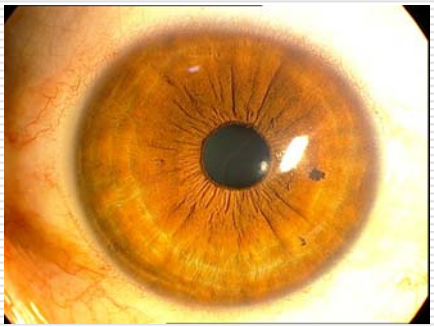
Background

Synonyms:

- Progressive Post- LASIK Keratectasia (PPLK)
- Iatrogenic Keratectasia
- Keratectasia after LASIK

Onset:

- Immediate (weeks) to many months after LASIK generally within 2 years
- Peak: 6-10 months

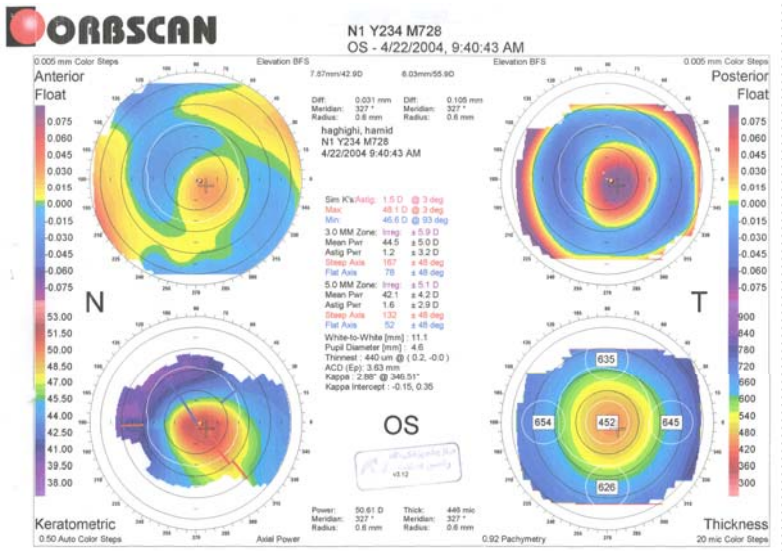


Incidence:

- 0.66%, relative uncommon
- Incidence is more than reported

Presentation & Clinical Exam

- ***Positive History*** **of Corneal Refractive Surgery**
- ***Corneal Findings: A*****nterior & Posterior Corneal Steepening**
  Irregular astigmatism,
  Thinning in the area of Ectasia

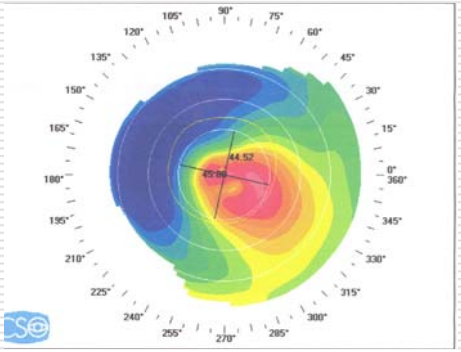


- ***General:***
  *** Increasing myopia, Progressive Keratometric steepening**
  *** Often with loss of UCVA & BCVA**
- **Iron ring may be visible**
- **Ectasia may appear in one eye while similar treatments in both**

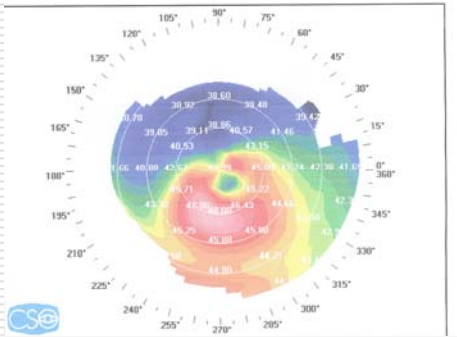
Presentation & Clinical Exam

Topographic findings:

- *Central Ectasia* with irregular astigmatism but good corrected acuity



- *Paracentral Ectasia* resembling Keratoconus, with irregular astigmatism and poor spectacle-corrected acuity



Pathophysiological Aspects of Post-LASIK Keratectasia

1- PPLK as Chronic Disease

- Is PPLK Similar to KCN??
  - Collagenase and Gelatinase activity
  - Increased interleukin-1 and prostaglandin activity
  - Rearrangement and altered adhesion of lamellae
  - These Not proven for PPLK but:
  - Loss of Keratocytes in anterior flap and interface
  - Anterior flap metabolic alterations due to neurotrophic keratectomy

2- Biomechanical process

A- Early effects of LASIK

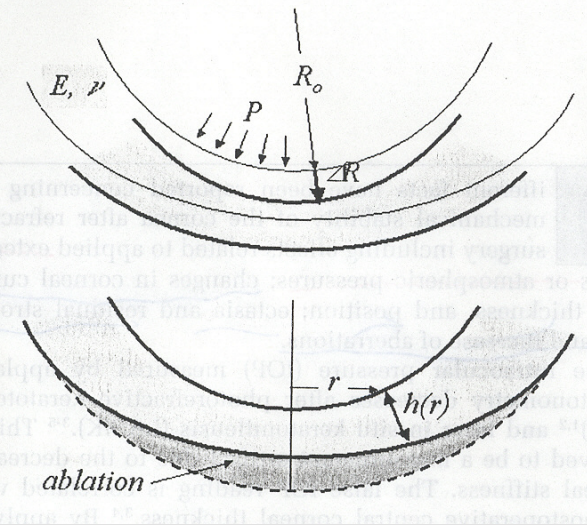
- Forward movement of posterior corneal surface **(usual finding after LASIK)**
- **Central as well as peripheral cornea is affected after central ablation (C. Roberts Theory)**

- Posterior stroma **after LASIK:**
  - *** Altered Proteoglycan composition**
  - *** Fewer Collagen cross links**
  - *** Reduced Keratocyte Density**

(Altered Stromal Remodeling and late Keratectasia)

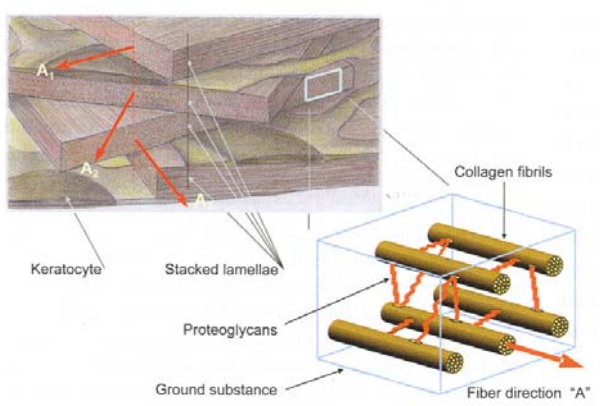
2- Biomechanical process

- IOP is responsible for posterior lamella bulging:
- Not Proven for normal range IOP (at least in short term)
- The smaller the radius of curvature the bulging will be smaller



B- Corneal Strain Redistribution after LASIK

- Cornea is weakest in bend and shear but strongest in tension due to Collagen fibers cross-linking (stress stiffening)
- Cornea is under strain even in normal physiological conditions
- After ablation:



  * Posterior lamellar tension is increased
  * Reduced interlamellar cohesive strength in the Infero-Central Cornea (where Ectasia is common)

C - Corneal Shape Changes after LASIK

- Peripheral cornea moves outward and forward (Roberts' Rubber-Band Theory)
- Limbus doesn't expand
- Surface area of posterior cornea remains constant

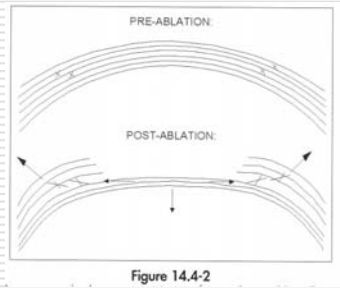
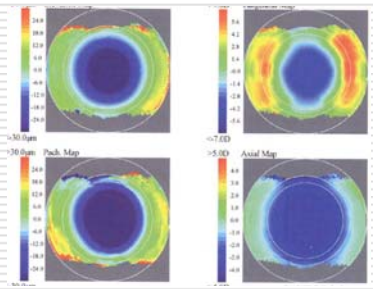


Figure 14.4-2



Central Corneal Movement

Transverse contraction of posterior lamellae

(Poisson's ratio)

(V= transverse strain / longitudinal strain)

D - Corneal Resistance to Fatigue

1- Resistance to IOP

2- Stable focusing of light

3- Resist Deforming Forces of Eyelids

Repeated microtrauma **e.g. Eye Rubbing**

⇩

Dynamic Fatigue

⇩

Ectasia

3- Combined process of Fatigue and Proteolysis

Static & Dynamic fatigue process of Cornea

⇩

Mechanical failure

⇩

Enzymatic Proteolysis ⇐ **Subclinical interface inflammation**

⇩

Molecular Collagen changes

Adhesion Protein changes

⇩

PPLK

Risk factors for PPLK in LASIK

Parameter	Safe	Warning
Young modulus	High	<1MPa
Poisson Ratio	Low	$(1-v)/E>0.7MPa^{-1}$
IOP	Low	>20mmHg
Loading pressure /elastic parameters	Low	(1-v)P/E > 0.001
Curvature radius	Small	With irregular topography
Preop. Corneal thickness	Thick	<500μ
Flap thickness	Thin	>160 μ
Ablation diameter	Small	>6mm
Attempted correction	Low	Depends on other parameters
Residual stromal bed	Large	Depends on other parameters

Theories about the Risk Factors for Keratectasia

1- Pre-existing Keratoconus or Forme Fruste Keratoconus

- **FFKC: * is abortive or early form of KCN**
  *** stable refraction and Corneal Curvature**
- **30% of Keratectasia cases had preop Forme Fruste KCN (FFKC)**
- **Post-LASIK Ectasia topography is different:**
  Preop Normal eyes ⇒ Central steepening
  Preop FFKCN eyes ⇒ Inferior steepening

2-Minimum Residual Stromal Thickness

- **Low Residual stromal thickness is mechanically Unable to withstand the Intraocular Pressure**

- ***Subtraction Technique:*** **Is Not Reliable**

Remained stromal thickness (RST)=
Corneal thickness (Pachymetry) – (flap thickness + ablated depth)

Flap thickness:- Inaccurate with different microkeratomes
- Thick flap doesn't prevent ectasia even predispose to Ectasia

Ablated thickness (depth): variable with Hydration

Anterior flap does not contribute to the biomechanical stability of cornea

Direct RST Measurement

- Inaccurate
- Laser ablation dehydrates stroma
- Overestimation of actual tissue removal
- Under- estimation of RST
- Anterior bowing of the posterior cornea occurs after LASIK
- RST must be determined after flap removal because of:
  - * Inaccurate flap thickness
  - * Epithelial hyperplasia

Minimum RST to prevent Keratectasia

- Variable Thickness reported: 200-320μ
- >18% corneal thickness ablation: increases risk
- Postop Corneal Thickness must be 55-60% preop thickness + not less than 475- 500 μ
- RST safety index:

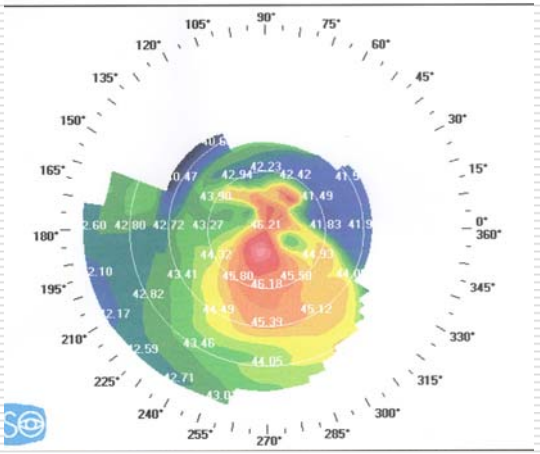
* > 300 microns	Safe zone
* 250-300 microns	Borderline zone
* < 250 microns	“Danger zone”

Factors affecting RST

- Preoperative Corneal Thickness
- Thickness of Corneal Flap
- Flap thickness is inaccurate:
  ± 80 microns

Even thickness through one flap is variable

- Amount of tissue removed by the Excimer laser



Mr. K.F 20 Y/O student underwent bilateral LASIK for -2.00 D myopia in his both eyes, pachy OU ~ 520 μ

OD had incomplete flap and incomplete operation (No laser!) for 2 times.

OS uncomplicated operation After 10 months:
RFN OD -4.25-1.50x 45° 20/30
OS plano 20/20
Thickness OD 410 μ

3 - Enhancement Procedures

- **Cornea tissue ablation will decrease RST**
- **Twenty two (22) percent of ectasia cases had at least one enhancement procedure**
- ***Regression! of myopia with or without astigmatism may be initiation of Ectasia***
- **If enhancement indicated, up to 2-3 diopters can be enhanced by ablation over the flap**

4- Preoperative Corneal Thickness

- **Current standard for pachymetry: Ultrasound Pachymetry**
- **Orbscan II (Optical slit):**
  - *** Mostly overestimates 20-30 μ**
  - *** Only one report shows underestimation**
  - *** Calibration Coefficient Factor: 0.92-0.96**
- **More unreliable in "non-virgin" Corneas**

Orbscan is Not suitable for Reoperation

4 - Preoperative Corneal Thickness

- Thin corneas with higher IOP may have a risk for forward shift of Posterior Corneal Surface after LASIK

- Posterior corneal surface shift is larger in those with lower preop Corneal Thickness, higher IOP and greater Myopia

5- Thick Corneal Flap

- Same Microkeratome and same blade produce ⇨ variable flap thickness
- Preoperative thin cornea ⇨ thinner flap (1)
- Thick flap ⇨ high risk for immediate Corneal Ectasia (even without ablation)

(1) Flanagan GF, Binder PS: Estimating residual stromal thickness before and after laser in situ keratomileusis. J Cataract Refrac Surg. 2003; 29: 1674-83

6- Laser Corneal Tissue Resection

- i.e corneal tissue removed by the excimer laser
- Inaccurate intraoperative pachymetry i.e immediate post-Laser
- Laser resection is variable with laser type and algorithms
- Munnerlyn's formula: resected thickness depends on diameter, ablation profile (optical zone) and diopters

Regional Anatomical Differences in Normal Cornea

- **Anterior 100-120 μ of the corneal stroma:**
  - *** More highly compact than posterior**
  - *** May be more resistant to mechanical deformation**
- **Hydration of Cornea and Refractive Index: changes across corneal thickness**
- **Posterior cornea is unable to withstand normal IOP**

7- Attempted Correction

- Most of Keratectasia have been in myopia over – 6.0D correction
- Exception: Some eyes with low attempted Correction have developed Ectasia
- Correction of regular Astigmatism does not increase the risk for Ectasia

8- Diameter of the Ablation

- **The larger the diameter of ablation, the more tissue is removed**
- **Faraj and coworkers:*“ An ablation diameter of 6.0 mm or greater is a risk factor”***
- **Difficult to conclude;**
  “diameter alone is a risk factor!!”

- **Increasing the ablation diameter increases the deformation of the posterior corneal surface**

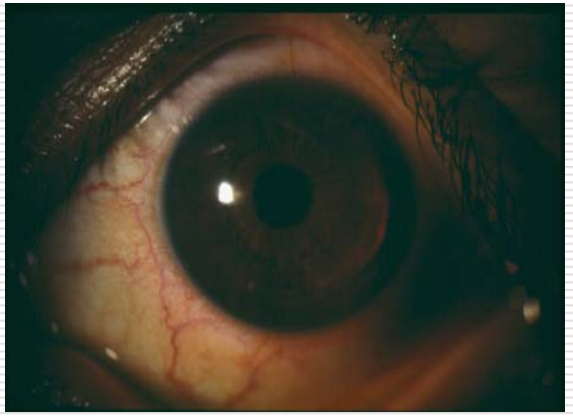
9-Other Risk Factors

History of Contact Lens use

- RGP contact lens wearers before LASIK need more Enhancement surgery
- Most of Keratectasia cases had no history of contact lens wearing: no direct relationship

Chronic Eye Rubbing

- May be a risk factor for development of ectasia



Prevention

- Due to difficulty in management ⇨ Prevention is better than treatment

1- Corneal Topography & Orbscan

- Mandatory preop to detect FFKN, KCN
- Standardized map is more accurate than absolute scale topography
- Consider Corneal Warpage as unstable and unreliable evaluation
- Pachymetry: >20 micron decrease in midperiphery
- Abnormal Posterior Corneal Elevation(>40 microns): in KCN diagnosis

Prevention

- **Pachymetry: >20 micron decrease in midperiphery**
- **Abnormal Posterior Corneal Elevation(>40 microns): KCN diagnosis**

2- Family history

Presence of history of KCN or FFKN in family:

" May be an Alarming Sign" !

Intraoperative Preventive Measures

- Measurement of flap thickness, posterior stroma (before and after ablation)
- Reduction of flap thickness (Thin-flap LASIK)
- Change procedure to surface ablation (in borderline cases)
- Reducing optical zones as far as possible
- Change the refractive surgery plan!
- Planning enhancement procedures with suspicions and caution

Postoperative Measures for Prevention

- Advise the patient not to rub even in long term
- Myopic regression may be due to Ectasia
- Pre-ectasia condition must be diagnosed by topography or Orbscan
- Topical IOP lowering medications: temporary
- Consider myopic regression may be due to lens Nuclear Sclerotic (N.S) changes

Treatment

- ***Depends on the Severity and Type of Keratectasia:***

- ***Glasses***
  - * May be helpful in early Stages of Central type
  - * Patient Not complete satisfied
  - * May be a transient management

Treatment

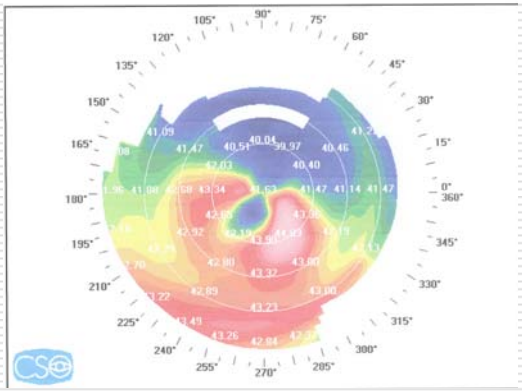
- **Contact lenses**
  - **Soft Contact Lens:**
    - may temporarily improve vision
    - Can be used in those intolerated RGP
  - **RGP Contact Lens:**
    - Ideal due to correction of astigmatic irregularity
    - More difficult fitting than Keratoconus patients
    - Usually patient not satisfied (previous CL-intolerant, psychological)

Treatment

- ***Excimer Laser Customized Treatment***

  Not effective, not proven

  Unpredictable, poor outcome



- ***Intracorneal segments (ICS or ICR)***

  Reduction of astigmatic irregularity and myopia

  Short term effective

  Difficulty in procedure (in comparison to KCN)

Treatment

Keratoplasty

Deep anterior lamellar keratoplasty (DLK)

- New modality
- Needs more experience
- Prolonged Visual Rehabilitation

Penetrating keratoplasty

- May need future Refractive Surgeries
- Will have its specific problems

Thank You for Your Kind Attention!!