



***Keratectasia  
After  
Laser in Situ Keratomileusis  
( LASIK)***

***Farid Karimian M.D***  
***Associate Professor of Ophthalmology***  
***Labbafinejad Medical Center***



***November 2006***

# Case Presentation

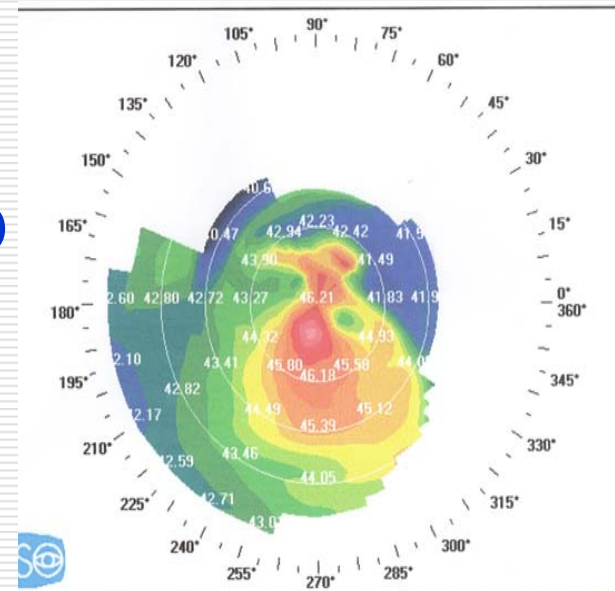
K.F 20 Y/O student underwent bilateral LASIK for -2.00 D myopia in his both eyes, Pachy OU ~ 520  $\mu$   
OD had incomplete flap and incomplete operation (No laser!) for 2 times.

OS uncomplicated operation  
After 10 months:

RFN OD -4.25-1.50x 45° 20/30

Thickness OD 410  $\mu$

OS plano 20/20



# ***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**



# ***Background***

---

- ✿ **Keratectasia is also reported after:**
  - \* **Myopic Keratomileusis**
  - \* **Hyperopic ALK (62%): “Controlled Ectasia**
  - \* **Radial keratotomy**
  - \* **Hexagonal Keratotomy**
  - **LASIK , and...PRK (1)**

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



# ***Background***

---

## **Synonyms:**

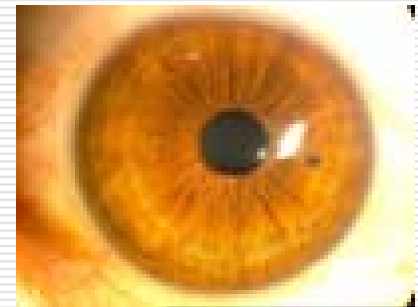
- Progressive Post- LASIK Keratectasia (PPLK)
- Iatrogenic Keratectasia
- Keratectasia after LASIK

## **Onset:**

- Immediate (wks) to months after LASIK generally within 2 yrs
- Peak: 6-10 months

## **Incidence:**

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



# Presentation & Clinical Exam

✿ **Positive History;** Corneal Refractive Surgery

✿ **Corneal Findings:**

**Anterior & 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**

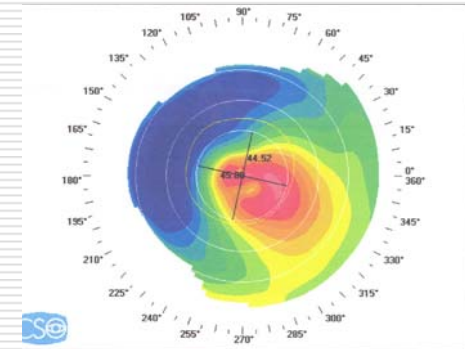
**Ectasia may appear in one eye while similar treatments in both**



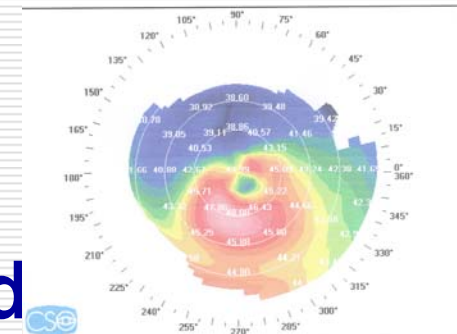
# Presentation & Clinical Exam

## 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***

---



# ***Regional Anatomical Differences in Normal Cornea***

---

- ✿ **Anterior 100-120  $\mu$  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 Stromal Thickness**
- ✿ **Posterior cornea is unable to withstand normal IOP**



# ***1- PPLK as Chronic Disease***

---

## ***Is PPLK Similar to KCN??***

- ❖ **Collagenase and Gelatinase activity**
- ❖ **Increased IL-1 and PGN activity**
- ❖ **Rearrangement and altered adhesion of lamellae**

**These are 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**

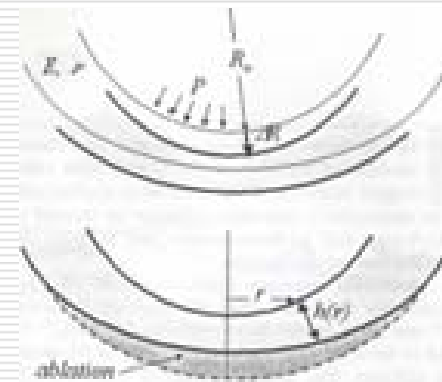
- ✿ **Forward movement of posterior corneal surface (usual finding after LASIK)**
  
- ✿ **Central as well as peripheral cornea is affected after central ablation (C.Roberts Theory)**
  
- ✿ **Posterior stroma after LASIK:**
  - \* **Altered Proteoglycan composition**
  - \* **Fewer Collagen cross links**
  - \* **Reduced Keratocyte Density****(Altered Stromal Remodeling and late Keratectasia)**



## *2- Biomechanical Process*

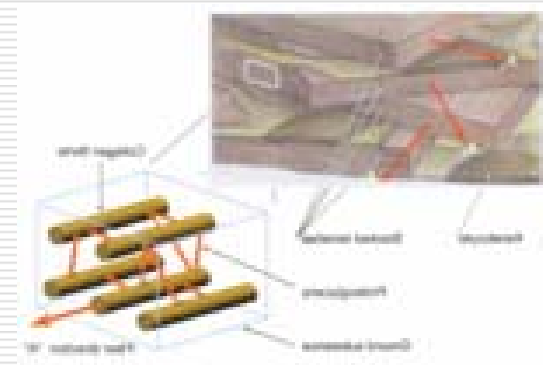
---

- 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



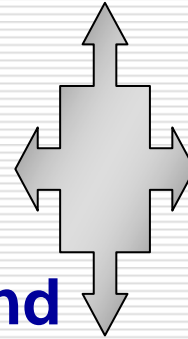
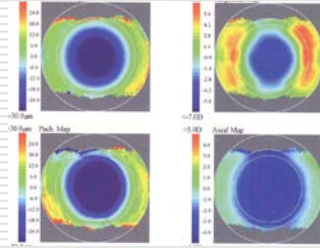
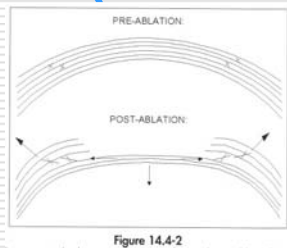
## B- Corneal Strain Redistribution after LASIK

- ✿ 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)



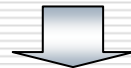
# C - Corneal Shape Changes after LASIK

- Peripheral cornea moves outward and forward (Roberts' Rubber-Band Theory)



**Central Corneal Movement**

- Limbus doesn't expand
- Surface area of posterior cornea remains constant



**Transverse contraction of posterior lamellae  
(Poisson's ratio)  
( $V = \text{transverse strain} / \text{longitudinal strain}$ )**



# ***D - Corneal Resistance to Fatigue***

---

**Cornea has Continuous Resistance to:**

**IOP**

**Deforming Forces of Eyelids**

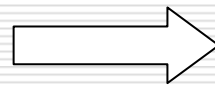


**Keep stable focusing of Light on Retina**

***Repeated Microtrauma* e.g. Eye Rubbing**



**Dynamic Fatigue**



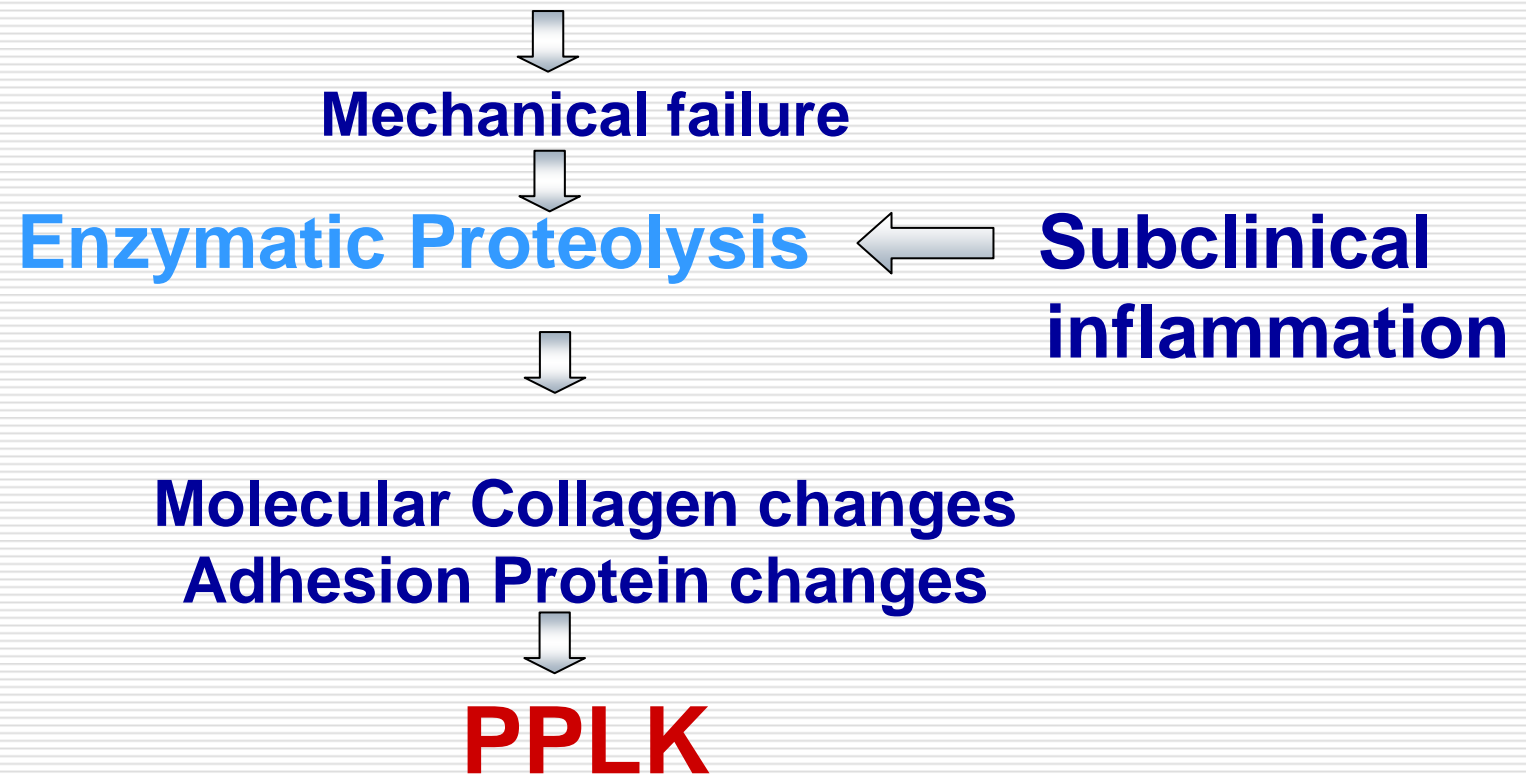
**Ectasia**



# ***3- Combined process of Fatigue and Proteolysis***

---

**Static & Dynamic fatigue process of Cornea**



# ***Risk factors for PPLK in LASIK***

<b><i>Parameter</i></b>	<b><i>Safe</i></b>	<b><i>Warning</i></b>
Young modulus	High	<1MPa
Poisson Ratio	Low	$(1-\nu)/E > 0.7\text{MPa}^{-1}$
IOP	Low	>20mmHg
Loading pressure /elastic parameters	Low	$(1-\nu)P/E > 0.001$
Curvature radius	Small	With irregular topography
Preop. Corneal thickness	Thick	<500 $\mu$
Flap thickness	Thin	>160 $\mu$
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*

---

- ✿ **Is NOT accurate**
- ✿ **Laser ablation dehydrates stroma**
- ✿ **Overestimation of actual tissue removal**
- ✿ **Under- estimation of RST**
- ✿ **Anterior bowing of the posterior cornea occurs after LASIK**
- ✿ **For Enhancement: RST must be determined after flap removal because of:**
  - \* **Inaccurate flap thickness**
  - \* **Epithelial hyperplasia**



# ***Minimum RST to prevent Keratectasia***

---

- **Variable Thickness reported: 200-320 $\mu$**
- **>18% corneal thickness ablation: increases risk**
- **Postop Corneal Thickness must be 55-60% preop thickness but not less than 475- 500  $\mu$**
- **RST safety index:**
  - \* **> 300 microns**                      **Safe zone**
  - \* **250-300 microns**                    **Borderline zone**
  - \* **< 250 microns**                      **“Danger zone”**



## 3 - Enhancement Procedures

---

- ✿ Cornea tissue ablation will decrease RST
- ✿ %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  $\mu$
  - 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**

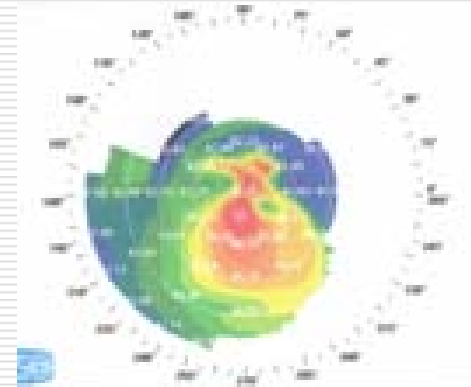


# 5- Thick Corneal Flap

---

Same **Microkeratome** and same blade produce  $\Rightarrow$  **variable flap thickness**

- **Preoperative thin cornea**  
 $\Rightarrow$  **thinner flap**
- **Thick flap**  $\Rightarrow$  **high risk for immediate Corneal Ectasia (even without ablation!!)**



## ***6- Laser Corneal Tissue Resection***

---

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



## ***7- Attempted Refractive 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 Zone***

---

- ✿ **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!!”**
- ✿ **The larger the diameter of ablation, the more tissue is removed**

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

---



## ***9- Other Possible Risk Factors***

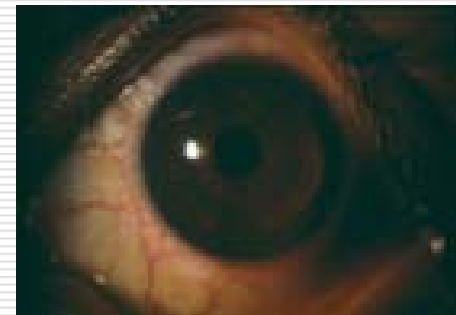
---

### ***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***

---

***Prevention is simpler than Treatment***

## ***1- Corneal Topography & Orbscan***

- Is Mandatory preop to detect FFKN and KCN
  - Standardized map is more accurate than absolute scale topography
  - ✦ Always Consider Corneal Warpage as unstable and unreliable evaluation
- 



# *Prevention*

---

## **KCN diagnosis:**

- Central Pachymetry Difference: >20 microns**
- Decrease in midperipheral Corneal Thickness**
- Abnormal Posterior Corneal Elevation(>40 microns) in Orbscan**

## ***2- Family history***

**Presence of history of KCN or FFKN in family:**

***“ May be an Alarming sign” !***

---



# *Intraoperative Preventive Measures*

---

- ✿ **Measurement of 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**
- ✿ **Planning enhancement procedures with  
suspicions and caution**



# *Postoperative Measures for Prevention*

---

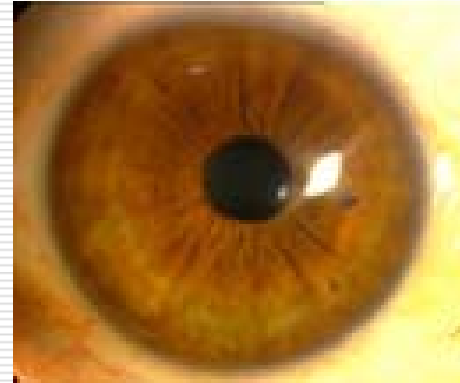
- ✿ Advise the patient **not to rub the eyes even in long term**
- ✿ Myopic regression may be due to **Ectasia**  
Also consider myopic regression may be due to lens Nuclear Sclerotic (N.S) changes  
Pre-ectasia condition must be diagnosed by topography or Orbscan
- ✿ **Topical IOP lowering medications: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



# *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)
- 

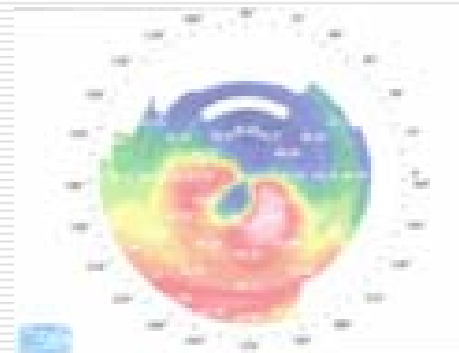


# *Treatment*

---

## **✿ *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 (DALK)*

- New modality
- Needs more Surgical experience
- Prolonged Visual Rehabilitation

### *Penetrating Keratoplasty (PKP)*

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



# *Conclusion*

---

**Post-LASIK Keratectasia is a Serious  
Complication of LASIK**

**There are Multiple Risk Factors which  
Most of them can be Screened and  
Diagnosed before and Intraoperatively**

**Management of this condition is Difficult,  
Try to Prevent its Occurrence !!**

---



---

***THANK YOU  
FOR YOUR  
KIND  
ATTENTION!!***

***Questions...?***

---

