Surgical Advances in Keratoconus

Keratoconus

- Ectatic disorder
- 1 in 1,000 individuals
- Starts in adolescence & early adulthood
- Uncertain cause
- 20% require corneal transplant

Innovations in Ophthalmology

- Cataracts
- Macular degeneration
- Retinitis Pigmentosa
- Keratoconus

New Surgical Advances

Diagnosis of Keratoconus

- Corneal Hydrops
- Munson’s sign
- Apical Scarring
- Vogt’s Striae
- Irregular Keratometry Mires
- Abnormal Computerized Topography
- High Coma
- Epithelial thickness abnormalities
- Posterior Corneal Curvature

Scheimpflug imaging

Keratoconus Detection

Keratoconus

Posterior Corneal Curvature
Suspicious of Keratoconus

> 2 D difference Inferior to Superior cornea at 3 mm optical zone

- Posterior bulge > 17 um
- Anterior bulge > 21 um
- Corneal steepening > 49 D
- Corneal thinning < 480 um

Wavefront Analysis

Wavefront Analysis: High Coma

Corneal Biomechanical Properties

- Ocular Response Analyzer
- Measure rigidity

New Diagnostic Testing =
Early Detection of Keratoconus

Corneal Collagen Cross-linking with Riboflavin (CXL)

- Cross-linking of the cornea to enhance rigidity
- Performed in Europe for 11 years
- New treatment in North America
- Keratoconus, pellucid marginal degen., ectasia, and post-RK

Derivation of Concept of CXL

- Diabetics do not develop keratoconus because of natural crosslinking from high glucose and UV light

CXL History

- Basic research from 1993 to 1997 by Theo Seiler & Eberhard Spoerl in Germany
- First patients treated in 1998
- Today over 300 centres in Europe are performing CXL
- Standard of care for keratoconus with progressive disease
Cross-Linking is Not New

- Hardening of polymers in material science over 70 years (silicone oil vs rubber ball)
- Dentists have used cross-linking for 25 years
- Normal aging of connective tissue involves cross-linking
- Progression of keratoconus slows down with age

Corneal Collagen Cross-Linking

- Creates additional chemical bonds between collagen fibers by means of photopolymerization

Corneal Rigidity Post-CXL

- 328.9 %
- CXL Procedure

CXL Technique

- Epithelium removed (8 mm)
- Riboflavin 0.1% drops applied for 30 minutes
- UV-A light (low intensity) 370 nm applied for 30 minutes
- Bandage SCL for 5 days

Power Density Check (3 mw/cm2)

Corneal Epithelium

- Barrier to Riboflavin penetration of stroma

Epithelium Removed

Riboflavin 0.1% Drops x 30 min

UV-A Light 370 nm x 30 min

Safety of Cross-Linking

How much UV – light gets into the eye?

Safety of UVA-Riboflavin

Cross-Linking of the Cornea

- Minimum thickness of 400 um, the corneal endothelium will not experience damage, nor will deeper structures such as lens and retina.
Corneas 300 to 399 um

- Induce corneal swelling with specially formulated drops
- Riboflavin without dextran
- Induces over 100 um of transient stromal edema
- Allows for safe CXL

Ectasia

Cross-Linking

Cross-Linking

Complications

Bochner Eye Institute & CXL

- Advised patients to obtain CXL treatments in Europe prior to January 2008
- Started CXL in January 2008 with full-informed consent
- Acquired Riboflavin drops & UV-A light source directly from Europe

CXL Patient Selection (805 Eyes)

- January 2008 to August 2009

CXL & Pachymetry N=30

CXL & Pachymetry N=30

CXL & Steepest Diopter

CXL & Curvature Change

- Change in steepest power or average Ks does not provide all the information
- Important to look at difference maps to appreciate change in curvature

CXL & Corneal Haze N=30

Line Change in BCSVA
Postop CXL

- Pseudodendrite during the first few weeks
- Vision maybe worse with glasses during first 1-2 months

Vision Worse 1-2 M Postop

CXL Complications (N = 805)

- Sterile Infiltrate 1
- Corneal ulcer 0
- Corneal melt 0
- Delayed epithelial healing >5 days 4
- Persistent corneal edema 0
- Cataract 0
- Macular edema 0

Postop CXL

- May return to CL wear 1-2 weeks postop
- CL power and fit usually unchanged
- Change in Rx may occur in 2-4 months
- Faint corneal haze noted after 2 months that decreases over 6-12 months

CXL Study in Keratoconus

- Pachymetry decreased in all eyes and then gradually increased by 9 to 12 M
- D of average flattening of steepest curvature
- Significant variation: No flattening to 8 D
- Curvature difference maps showed both flattening and steepening to improve shape

CXL in Keratoconus

- Improvement in BCSVA of 1 or more lines in 60.0 %
- No evidence of progressive disease
- Safe and effective in the short-term

Corneal Rings for Keratoconus

- Developed for low myopia
- Unsuccessful in competing with PRK/LASIK
- Resurgence with treatment of keratoconus
- Excellent modality to treat irregular astigmatism and enhance CL wear
• Potential to improve UCVA & BSCVA

Corneal Rings & Keratoconus

• Does not prevent progression of disease
• Useful as an adjunct to CXL to reduce irregular astigmatism
• Primary procedure in older patients (>45 years) with corneal stability

Corneal Ring Procedure

• Corneal channel 400 um
• Intralase vs mechanical construction
• Incision placed in steep meridian
• 1 or 2 rings inserted
• 1 suture inserted

Preop Postop (3 M)

• UCVA 20/70
  • -1.00 -2.75 x 63  20/30
  • 1 ring (400 um)
  • UCVA 20/25
  • -0.25-0.75 x 25  20/20

Preop Postop (3 M)

• UCVA 20/50-
  • -1.25-1.25 x 155  20/30
  • 2 rings (300 um)
  • UCVA 20/25
  • +0.50 -0.50 x 160  20/20

Preop Postop (3 M)

• Contact lens intolerant
• 1 ring (450 um)
• Able to wear RGP lens

Postop Corneal Ring

• Patients usually comfortable
• Resume CL wear at 2 weeks (check power/fit)
• Suture removed at 2 months
Recheck CLs and glasses 1 M after suture removal

**Corneal Ring Complications**

- Loose suture
- Infection
- Extrusion anteriorly
- Subluxation

**Corneal Ring Procedure**

- Relatively easy procedure for patients
- High level of patient satisfaction
- Main goals are to flatten corneas, reduce irregular astigmatism, and allow contact lens wear

**Ectasia Patients**

- Expectations different from keratoconus patient
- Desire improvement in UCVA
- More likely to proceed with additional surgical options: Intracorneal rings, Phakic IOL, Topolink PRK, or standard PRK

**Ectasia Post-LASIK**

- 42 year old male
- Major in Canadian National Defense
- LASIK 2002 (Centre no longer in business)
- Requirement of 20/30 BCSVA
- February 2008
- OD -1.75-2.75 x 84  20/80
- OS -2.00-2.50x 125  20/50

**CXL + Intacs OU**

- March 27, 2008 CXL OD
- April 4, 2008 CXL OS
- June 12, 2008 Intacs (1 Ring 450 um) OU
- Oct 10, 2008 UCVA OD 20/30 OS 20/25
- Manifest Refraction OD +0.75 20/30+
- Manifest Refraction OS -0.50 20/20
- May 2009 Stable
- Preop 12 M Postop
- Preop 12 M Postop
• IntraCorneal Rings
• Useful adjunct to CXL
• Potential to reduce irregular astigmatism and enhance BCSVA and/or contact lens wear
• Can be performed at the same time as CXL, prior to CXL, or after CXL

Topographically-Guided Ablations

• PRK procedure
• Irregular corneas
• Improve curvature of cornea
• Enhance BCSVA or allow SCL wear

Topographically-Guided Ablation

• Developed by Theo Seiler from Germany
• Over 22,000 curvature points on the cornea
• Linked to the excimer laser
• Main indications are irregular astigmatism, decentered ablations, small optical zones

Topography Ablation Treatment

Topolink Ablation

• Topography data transferred to laser
• Treat irregular astigmatism initially and then residual refractive error at another time
• Surface Ablation

Topographically-linked Ablations

• Promising adjunct to CXL
• Reduce irregular astigmatism
• Allows improvement in BCSVA or SCL wear

Post-Radial Keratotomy

• Fluctuation in vision
• Hyperopic shift

10 Years Post-RK (8 cuts)

• +9.00-1.00 x 85 20/40  +9.5 -1.25 x 65 20/40
• CXL OU June 2008

10 Years Post-RK + 6 M Post-CXL
"My vision is stable from morning to night. I can now drive home from work with good sight"

15 Years Post-RK + 12 M Post-CXL

"I used to have 20 pairs of glasses at home. I now find one pair is satisfactory"

CXL & Post-RK

- Early results look impressive
- Is there long-term stability?

Phakic IOLs

- Correct myopia, hyperopia, and astigmatism
- No tissue is removed
- IOL is custom ordered
- Keratoconus (high refractive error, 20/40 or better BCSVA)

< 45 years: CXL + Intacs + Phakic IOL

> 45 years: Intacs + Phakic IOL; or Phakic IOL

Slitlamp Exam ICL

Phakic IOL for Keratoconus

- 47 year old male; Stable Rx; CL intolerant
- OD -9.25 -3.00 x 075  20/30
- OS -9.00 -2.00 x 105  20/30
- Phakic IOL for Keratoconus
- Toric ICL OD then OS (January 2006)
- 3.5 years postop UCVA OD 20/25 OS 20/20-

Educating Keratoconus Patients

- CXL is becoming the standard of care for keratoconus patients under 45 years of age
- Obligation to inform patients that CXL can halt disease progression
- The earlier the treatment the better the prognosis
- Patients will continue to require glasses or contact lenses

Summary

Thank You