Proverbs

- The physician is only nature’s assistant—*Galen*

Proverb

- Surgery is an admission that we have failed medical treatment—*Anonymous*
Proverb

❖ Surgery does the ideal thing, it separates the patient from the disease—Logan Clendening, MD

Surgery & Surgeons

"Whoa! That was a good one! Try it, Hobbes—just poke his brain right where my finger is.

"Well, I guess that explains the abdominal pains."

By Gary Larson
Surgical Decisions

*Between two evils, I always like to take the one I’ve never tried before*
—Mae West, American actress
1893-1980

Lecture Outline

- Tissue glue Advance
- Management of OSSN
- Corneal Transplantation: Selected techniques and advances
- Surgical Options for Keratoconus
I learned a long time ago that minor surgery is when they do the operation on someone else, not you
—Bill Walton, NBA legend

Tissue glue

Indications
- Perforated bacterial ulcers
- Neurotrophic ulcers seen with HZV, HSV, s/p surgery for acoustic neuroma
- Corneal surgery wound leaks
Tissue glue: Neurotrophic ulcer

- Sterile cyanoacrylate glue
- (e.g. dental glue (Periacryl, Histoacryl [Canada]))

Tissue glue: Neurotrophic ulcer

- Resistant to patching, punctal plugs, bandage contact lenses, AMT
Perforations: cyanoacrylate glue

- Emergency closure
- Usually only temporizing measure while surgery is being scheduled

New ReSure Corneal Sealant

- Is there a place for clinic use?
  - Currently approved for cataract surgery
Resure Corneal Sealant

- ReSure tissue glue
  - Polyethylene glycol (PEG) hydrogel technology

Corneal Laceration Repair

- ReSure tissue glue
  - Potential adjunct for complex laceration repair
OSSN: Ocular surface squamous neoplasia (CIN)

- Often overlooked with pterygium dx

Traditional:
- Excisional biopsy with adjuvant MMC, cryopexy and AMT
  - Advantage is histologic confirmation
**OSSN: Ocular surface squamous neoplasia**

- **Recent trend:**
  - Topical MMC 0.4 mg/ml
  - Topical Interferon (IFN a2b-1M units/ml)
  - Topicals have equal or fewer recurrences and later time of recurrence than surgical treatment
  - Most recurrences within 2 years

Besley et al AJO 2014 JFeb; 157(2):207-93

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**Corneal Grafting: Selected Technique Update**
CORNEAL GRAFTING UPDATE

Outline

- Corneal transplantation
  - ANTERIOR LAMELLAR (ALKP)
    - Tectonic/ patch grafts (LKP)
    - Deep Anterior Lamellar (DALK)
  - ENDOTHELIAL KERATOPLASTY (EK)
    - DLEK—now rarely used
    - DSEK; DSAEK
    - DMEK; DMAEK
  - PENETRATING KERATOPLASTY (PK)
    - Manual trephine PK (PKP)—most common
    - Femtosecond (FPK)
  - KERATOPROSTHESIS
    - Temporary
    - Permanent (KPro)

Lamellar Keratoplasty

- Takes advantage of lamellar architecture
ANTERIOR LAMELLAR/TECTONIC

◆ TYPES
  - Free hand
  - Trephine
  - Crescentic
  - Automated microkeratome
  - Femtosecond laser

ANTERIOR LAMELLAR/TECTONIC GRAFTING

◆ INDICATIONS
  - Descemetocele/perforations
  - Corneoscleral limbal melts
  - Anterior stromal scars (e.g. herpetic)
  - Anterior stromal dystrophies (granular, lattice)
  - Chemical burn scars (after limbal grafting)
  - Ectasias (keratoconus, pellucid, keratoglobus, post LASIK)
  - Progression to transplant may become a historical curiosity!
TECTONIC ANTERIOR LAMELLAR KERAToplasty (ALKP)

Indications
- Severely thinned corneas, descemetoceles & perforations
  - Bacterial
  - Viral
  - Fungal
  - Amebic
  - Neurotrophic
  - Mooren’s ulcer
  - Rheumatologic conditions

ALKP PRINCIPLE
(Anterior Lamellar Keratoplasty)
Large Diameter ALKP for Keratoglobus

LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

Keratoglobus
LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

Keratoglobus

- D.G. 33yo, Ehlers Danlos Type V or VI (very rare, no aortic involvement)
  - Thinned to 5-10% residual stroma, limbus

LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

Keratoglobus

- Too thin for riboflavin CXL
- Must preserve limbal stem cells: “tuck” behind Palisades of Vogt
LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

Keratoglobus: D.G.: 33 yo wm, OD: 47 D cornea, 5.5 D irregular toricity

Preop

LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

Keratoglobus

◆ D.G. 33yo, Ehlers Danlos Type V or VI
LARGE DIAMETER ANTERIOR LAMELLAR KERATOPLASTY

D.G.
Postop 43D
3.6D cyl

CRESCENTIC ALKP
Crescentic Tectonic ALKP: Indications

- Pellucid marginal degeneration

- Mooren’s ulcer
Crescentic Tectonic ALKP:
Indications

- Rheumatoid melt

Crescentic Tectonic ALKP:
Indications

- Surgical misadventures
Tectonic ALKP

- Crescentic Keratoplasty

(Modified from Petti TH: Refrac Corneal Surg 7:28, 1991.)
Tectonic ALKP

◆ Crescentic Keratoplasty

ANTERIOR LAMELLAR/TECTONIC (ALKP)

◆ Newer types
  - Microkeratome
  ◆ Several keratome designs
ANTERIOR LAMELLAR/TECTONIC

- Newer Types
  - Femtosecond laser
  - Near infrared light

Anterior Lamellar Keratoplasty

Traditional ALKP Advantage
- Relatively easy to perform

Disadvantages
- Interface haze reduces visual outcome
DEEP ANTERIOR LAMELLAR KERATOPLASTY (DALK)

Advantages
- Eliminates risk of endothelial graft rejection—less follow up once sutures out!
- Less interface haze/better vision potential
- Gaining popularity for keratoconus (vs PK)

Disadvantages
- Recipient cornea must not be too thin
- No panstromal scarring
  - Descemet/scar attachments cause perforation
- Time consuming
- Must be ready to convert to PK (back up corneal tissue!)
DEEP ANTERIOR LAMELLAR KERATOPLASTY (DALK)

CURRENT TREND: DALK IF POSSIBLE

- If host endothelium is normal
  - Current trend toward more DALK and less Penetrating Keratoplasty (spares host endothelium)
**DALK**

Deep Anterior Lamellar Keratoplasty

- Indicated for Bowman’s/anterior/ & **posterior** stromal replacement

**Indications:**

- Anterior, mid & certain posterior stromal scarring & vascularization
- Anterior corneal dystrophies
  - Anterior Basement membrane/
  - Reis Buckler’s, Honeycomb
  - Granular
  - Lattice
  - Macular
- Keratoconus
- Post Lasik Ectasia
DALK (Deep Anterior Lamellar Keratoplasty)

DALK:
- Historically inadequate techniques for preservation of Descemet’s & endothelium with DALK
- Perforations were frequent

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I don’t know what the problem is, but I am sure it can be solved without resorting to violence

--Arnold Schwarzenegger (Twins)
Big Bubble DALK

www.corneaclinic.com

Big Bubble DALK

www.corneaclinic.com
Donor Tissue for ALK/ DALK

- Traditionally fresh whole globe or short term preserved cornea
  - Generally use tissue without adequate endothelial cell counts for endothelial grafting
- DALK tissue: surgeon simply strips endothelium from donor

ALK: Eye Bank Can “Precut” Patch Tissue to Thickness Required
Making the Cut With Microkeratome

Precut Lamellar Graft Tissue Delivered to O.R.
Donor Tissue for ALK

- Traditionally fresh whole globe or short term preserved cornea
  - Generally use tissue without adequate endothelial cell counts for endothelial grafting
- Recently new Halo “sterile cornea” Portland OR

HALO STERILE CORNEA

- Off the shelf immediate availability
- Sterile!
- Normal structural strength
- No viable cells, e.g. endothelium, keratocytes
- Potentially less risk of rejection
◆ DALK Surgery

Endothelial Replacement
Endothelial Keratoplasty (EK)
Endothelial Replacement
Endothelial Keratoplasty (EK)

Reasons for EK:

- Eye is **stronger**, resistant to injury
- Healing time significantly **shorter**
  - Quicker return to referring eye doctor
- Visual recovery **faster**
  - Appeals to younger patients
  - Appeals to older patients (~1 yr vs 8 years)
- Minimal **suture** use; suture related complications rare
- Minimal change in **refractive error**—return to spectacle correction for BCVA

Endothelial Replacement
Endothelial Keratoplasty (EK)

- DLEK (Deep Lamellar Endothelial Keratoplasty)—Now rarely used
- DSEK/DSAEK: Descemet’s Stripping (Automated) Endothelial Keratoplasty
  —Most frequent EK technique
- DMEK/DMAEK (Descemet’s Membrane (Automated) Endothelial Keratoplasty)
  —Gaining use
Endothelial Replacement
Endothelial Keratoplasty (EK)

- 2012/2013 more EK’s than PK’s
- 24,000 DSEK/DSAEK
- ~1500 DMEK (EBAA 2013)

DSAEK

- Descemet’s stripping automated endothelial keratoplasty
- Technically easier than DLEK
- May be performed with “pre-cut” donor tissue from eye bank saving OR time
DSAEEK PROCEDURE

Preparation of the Recipient

PK: rejected graft
--Now an “easy” solution!
PK: rejected graft—Candidate for DSAEK
- Stromal edema not too chronic
- Good pre-rejection Va, VF & topography

DSEK: clearing graft
DSEK: clearing graft

DMEK

- Descemet’s membrane endothelial keratoplasty—
  - Beginning of the last *surgical* frontier?
ENDOTHELIAL KERATOPLASTY

- Descemet membrane endothelial keratoplasty (DMEK)
  - Descemet’s stripped from recipient as in DSAEK
  - Donor Descemet’s prepared by “big bubble” technique (in O.R. or Eye Bank) or “scuba” technique
  - Descemet’s placed on “carrier” ring or rolled into a “shooter”
  - Injected into AC and tediously unfurled
  - Air bubble injected

ENDOTHELIAL KERATOPLASTY

- DMEK Advantages:
  - Descemet’s may stick better than donor disk of DSEK/DSAEK—so far NOT
  - May choose to transplant Fuchs patients at an earlier stage
  - Virtually “zero” refractive error change

- DMEK Disadvantages
  - Technically difficult to prepare donor
  - Technically difficult to unfurl donor in the anterior chamber
  - May take week(s) to adhere
New Directions in Eye Banking
DMEK/DMAEK Preparation

Chris Stoeger, CEBT, CTBS

DMEK/DMAEK: The final frontier?

DMEK: Only Descemet's membrane transplanted

DMAEK: Thin rim of stroma

Courtesy of Mark Terry, MD - Devers Eye Institute
Surgical Challenges with DMEK (and DMAEK)

◆ DMEK:
  --Risky harvesting of donor Descemets’ membrane with risk of tearing the tissue (another donor eye may be needed!)
  --Difficult unfolding and centering of “scroll” of donor tissue in the recipient anterior chamber
  --Getting graft to adhere

DMEK Insertion

A  B
C  D
E  F
DMEK at 6 days post-op:
Note clarity of graft and absence of visible graft edges

BSCVA = 20/30-
DMEK Preparation

◆ DMEK
Biggest DMEK challenge

- Graft attachment & need to rebubble/position patient for days

DMEK...

- Descemet’s membrane endothelial keratoplasty—
  - Beginning of the last surgical frontier?
  - Maybe not!
    - Central Descemet’s stripping (3-4 mm)
    - +/- Rock inhibitor administration
    - May result in enough endothelial regeneration to restore vision (No graft!)
    - Fuchs may not be a Dystrophy!
Descemetorhexis alone in select cases

Maybe less (surgery) is more!
Penetrating Keratoplasty
(full thickness corneal graft)

- Still ~20 K performed in US per year

Figure 1: Domestic Surgery Use of U.S. Supplied Intermediate-Term Preserved Tissue

Penetrating Keratoplasty

- Full thickness corneal graft for all functional layers of the cornea
Penetrating Keratoplasty

- First PK performed by Eduard Zirm, 1905, Moravia, for alkali burn

Indications:
- Fuchs endothelial dystrophy
  - Chronic edema/ scarring
- Pseudophakic corneal edema/ bullous keratopathy
Penetrating Keratoplasty

Indications:
- Keratoconus/
  Post-LASIK ectasia
  --with deep scarring

- Herpetic corneal scars

Penetrating Keratoplasty

Indications:
- Traumatic scars

- Dystrophies
Penetrating Keratoplasty

Indications:

- Congenital opacities e.g. Peter’s anomaly
- CHED
- Therapeutic: Non-responsive infective ulcers e.g. mycobacteria, fungus

Penetrating Keratoplasty

Trephines

- Donor
Penetrating Keratoplasty

Trephines
- Donor

Penetrating Keratoplasty

Trephines
- Recipient
Penetrating Keratoplasty

Trephines
- Recipient

Penetrating Keratoplasty

May be combined with
- Cataract surgery
- IOL removal/ exchange
- Vitrectomy
Penetrating Keratoplasty

- Removal of recipient’s cornea
- Donor cornea placement

Suture techniques
- Interrupted
- Running
Penetrating Keratoplasty

- Sutures placed
- Completed cornea transplant

Penetrating Keratoplasty

Numerous potential complications
- Wound problems associated with sutures:
  - Indolent erosions
  - Wound leak
Penetrating Keratoplasty

Numerous potential complications
- Wound problems/Wound mismatch

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Infection
Penetrating Keratoplasty

- Graft failure

- Rejection

Penetrating Keratoplasty

- Recurrence of pathology
  -- dystrophies
  -- keratoconus
Penetrating Keratoplasty

- High and Irregular Astigmatism
- Endophthalmitis
- ...etc; hence interest in lamellar surgery

Status of Penetrating Keratoplasty?
Status of PK (Penetrating Keratoplasty)?

- Major hurdles
  - Wound/ interface issues
    - Healing time
    - Suture complications
    - Increase terminal wound strength (>70%)
  - Topography: prolate/ non-astigmatic
  - Reduce rejection potential

Femtosecond PKP
Penetrating Keratoplasty (FPKP or FLAK))

- Femtosecond PK
  - Effort to reduce postop problems
    - Improved wound architecture
    - Greater wound strength
    - More rapid wound healing
    - Earlier suture removal
- But, Greater cost/ resources

Penetrating Keratoplasty

- Femtosecond PK

Mushroom incision profile
The mushroom-shaped incision preserves more host endothelium than the traditional trephine approach.\(^1\)

Top-hat incision profile
The top-hat-shaped incision allows for the transplantation of large endothelial surfaces.\(^3\)

Zig-zag incision profile
The zig-zag-shaped incision provides a smooth transition between host and donor tissue and allows for a hermetic wound seal.\(^1\)
Penetrating Keratoplasty

- Femtosecond Laser PK (FLAK)

1 week after surgery | 3 months after surgery | 6 months after surgery

Penetrating Keratoplasty

- Femtosecond PK (FLAK)

<table>
<thead>
<tr>
<th>Zig-zag incision</th>
<th>IEK 3 months after surgery</th>
<th>Trephine 1 year after surgery</th>
</tr>
</thead>
</table>

- The zig-zag-shaped incision has shown a smooth corneal contour immediately after surgery, with less distortion of the corneal optics and less astigmatism.¹
- IEK result at 3 months after surgery = 0.5 diopter of astigmatism.¹
- Typical result with standard trephine-cut PKP at 1 year after surgery = 8 diopters.¹
Lecture Outline

- Tissue glue Advance
- Management of OSSN
- Corneal Transplantation: Selected techniques and advances
- Surgical Options for Keratoconus

Surgical Management of Keratoconus: A new paradigm?
Surgical Options for Keratoconus

- Corneal Cross-linking (UVA-riboflavin collagen crosslinking)
- Rose Bengal-visible light crosslinking
- Intacs, often combined with CXL
- Anterior (ALK, DALK) and Penetrating Keratoplasty (PKP)

Goal for Keratoconus

- Kill off need for corneal transplants!
Corneal Cross-Linking (CXL)

- Paradigm shift for management of ectasias
  - Riboflavin/ UVA light
  - Rose Bengal/ white light

A government bureau is the nearest thing to eternal life we’ll ever see on this earth
—Ronald Reagan (1911-2004)
You can always count on Americans to do the right thing—after they’ve tried everything else

—Winston Churchill
Grafts for Keratoconus & Ectasias

- Will grafts be a curiosity of the past?
  - Riboflavin UVA corneal cross-linking

Riboflavin/UVA Crosslinking

- FDA-monitored clinical trials in progress, possible approval this year (Avedro, Inc)
- Multiple studies: may slow or stop keratoconus progression
- Flattening of up to 1D at 3-6 months
- Trend toward improved BCVA
- No major SEQ changes
- Less effective for higher K’s
- Failure rate, loss of BSCVA, sterile infiltrates, scars, potential risks to be determined

Wittig-Silva et al 2008 Australia; Seiler et al 2009 Switzerland
Riboflavin/UVA Crosslinking

- Cornea must be thicker than **300 microns** to prevent damage to endothelium
- New “standard of care” may be to treat keratoconus at *first sign* of ectasia
- Onset *teenage* years potentially most benefited from crosslinking
- New “epithelium on” techniques being studied
  - Greater ease of procedure
  - Greater comfort for patient

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**Riboflavin/UVA Crosslinking**

- Epithelium “off” procedure: 1:48
Surgical Treatment of Keratoconus
New Paradigm

- ICRS for early contact lens intolerance/ apical staining/ early scarring
- CXR after ICRS to inhibit further progression of keratoconus
  ...Avoids corneal transplantation

INTRACORNEAL RING SEGMENTS (ICRS) FOR KERATOCONUS
Gene Reynolds, O.D.
1921 - 1994

- Oklahoma optometrist first conceptualized the idea in 1978
- One of the early medical champions of contact lenses in the U.S.
- Developed CorneaScope in late 1960s - led to today's topography

1984
Adjustable Ring
As conceived by Dr. Reynolds
ICRS

- INTACS (WORLDWIDE USE)
- FERRARA RINGS (NON-USA)
- OTHERS (NON-USA)

**Intacs Design Features**

- 150° Arcs PMMA
- Precision Lathe-Cut to ± 0.01mm
- Hexagonal-Shaped Section of a Cone
- Inner Diameter = 6.8 mm
- Outer Diameter = 8.1 mm
- 2 Positioning Holes for Manipulation
- Intacs placement:
  - In peripheral cornea
  - Between stromal layers
Intacs Flexibility

- Maintains Original Prolate Corneal Morphology
- Additive
  - Removable/Replaceable
- Large, Clear Central Optical Zone

Indications for Intacs

Intacs for Keratoconus:

FDA IDE for:

Intended for Reduction or Elimination of Myopia and Astigmatism in Patients with Keratoconus who are:

- No Longer able to Achieve Adequate Vision with Contact Lenses or Spectacles
- Beginning to scar central cornea (punctate/swirling epitheliopathy)
Indications for Intacs

Intacs for Keratoconus:
– FDA IDE:

◆ Goal: Restore Functional Vision/ ability to continue contact lens wear/ Stop the apical scarring/ Potentially Defer PKP
◆ 21 Years of Age or Older
◆ Clear Central Corneas
◆ Corneal Thickness of 450 Microns or Greater at the Proposed Incision Site
◆ PKP or DALK as Remaining Option to Improve Functional Vision

Keratoconus Lifecycle
New Treatment Continuum

Today:
• Patient told they have Keratoconus or are Suspect
• Patient Educated on Current and Future Options to Treat their Condition (Including Intacs)
• Fit with Glasses or Contact Lenses
• Fit with Gas Perm or Specialty Contact Lenses and told about Intacs
• Re-Fit with Specialty Contact Lenses
• Becomes Contact Lens Intolerant
• Get Intacs
• Potentially Defers a Corneal Transplant
New Keratoconus Lifecycle?

- Keratoconus diagnosed
- Corneal Cross-linking performed
  - Add Intacs if advanced disease
- Spectacles or Contact Lenses fit
- Corneal grafts (PK, DALK) for KCN will become increasingly rare

Surgical Options for Advanced Keratoconus

- Intacs
- DALK
- Penetrating keratoplasty (PKP)
Surgical Options for Advanced Keratoconus

Intacs
-0.75

Transplant
+8.00 -2.00 X 180°

Results
Case Example 1 – Pre-Op

Anterior
Posterio

UCVA CF
BCVA: 20/50
MR: -7.00 -6.00 @ 60
Max K: 46.60 @ 175
Custom RGP Intolerant
Case Example 1 – Post-Op

UCVA: 20/80
BCVA: 20/30
MR: -2.00 -2.75 @ 60
Max K: 43.40 @ 14

Soft Toric

Case Example 2 – Pre-Op

UCVA: CF
BCVA: 20/50
MR: -4.75 + 5.00 @ 20
Max K: 55.78 @ 90

Custom RGP Intolerant
Case Example 2 – Post-Op

UCVA 20/40
BCVA: 20/25
MR: -2.00
Max K: 51.69 @ 89
RGP Tolerant

Case Example 3 – Pre-Op

UCVA CF
BCVA: 20/45
MR: -6.25 -4.75 @ 175
Max K: 54.43 @ 79
Custom RGP Intolerant
Case Example 3 – Post-Op

UCVA 20/80
BCVA: 20/30
MR: -0.50 -3.00 @ 135
Max K: 51.69 @ 89
RGP Tolerant

ICRS

- Femtosecond assisted Intacs procedure
Progressive keratoconus in contact lens wearers/ relative intolerance:
- Preponderance of papers support ICRS followed by riboflavin CXR to prevent further progression
CORNEAL SURGERY UPDATE
Summary

Take Home:

- Selective replacement of corneal lamellae more common
  - Faster healing and return to the primary eye care provider
  - Faster return to successful spectacle or contact lens wear
  - Often less chance of rejection
  - Better patient acceptance!
  - Can salvage previously rejected or failed PK’s!

CORNEAL SURGERY UPDATE
Summary (cont)

- Surgical Management of Keratoconus moving away from corneal grafting:
  - The evolving paradigm is to
    - Perform CXL as soon as diagnosis of progression has been established, or young age of onset
    - Keep patients in spectacles, or contacts
    - ICRS (Intacs) to extend successful contact lens wear in more advanced disease
Doctors are men who prescribe medicines of which they know little, to cure diseases of which they know less, in human beings of whom they know nothing.
—Voltaire, 1694-1778
French enlightenment writer, philosopher

And in the end, it is not the years in your life that count, it’s the life in your years
—Abraham Lincoln, 16th US President (1809-863)
Terry E. Burris, MD

Northwest Corneal Services
Portland, OR

Co- Medical Director, Lions VisionGift Oregon
Associate Clinical Professor of Ophthalmology
Oregon Health Sciences University