Fitting the Troubled Cornea

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Disclosure

- Consultant:
  - Alcon
  - Allergan
  - NovaBay
  - Valeant

- President EyePrint Prosthetics

General Fitting Principles

- Avoid mechanical pressure on the cornea
- Spread bearing area to periphery
- Avoid Limbal irritation and inflammation
- Avoid endothelial cell stress by removing oxygen barrier to endothelium
- Long term wear of any low Dk lens contributes to polymegathism and pleomorphism.

Initial Lens Selection

- Typically your choice of a lens design is based upon
  - Unique characteristics of a specific design and the disease you are working with
    - Keratoconus
    - Post penetrating keratoplasty
    - Post refractive
    - Ocular Surface disease
    - Endothelial Cell health

Today’s Options

- Gas Permeable Lenses
- Soft Lenses
- Hybrid Lenses
- Scleral Lenses
Question to ask yourself: Do I have enough sagittal depth? Where do I need to make changes? central intermediate peripheral

Changes in lens design

Scleral Lens Design

K'S VERSUS SAG

SAGITTAL DEPTH

44.00 44.00

44.00

44.00

44.00

44.00

44.00
**SAGITTAL DEPTH**
- Sag depth = \( \frac{R - \sqrt{R^2 - (1-SF)\times C^2}}{1-SF} \)
- \( R \): apical curve radius
  (Base curve)
- \( SF \): shape factor
  (Peripheral curves)
- \( C \): visible iris diameter/2
  (Lens diameter)

**CHANGING SAGITTAL DEPTH**
- **Increase**
  - Steepen base curve
  - Steepen/lengthen peripheral curves
  - Intermediate
  - Limbal
  - Peripheral
  - Increase diameter of lens or optic zone
- **Decrease**
  - Flatten base curve
  - Flatten/shorten peripheral curves
  - Intermediate
  - Limbal
  - Peripheral
  - Decrease diameter of lens or optic zone

**FACTORS WHICH AFFECT SAGITTAL DEPTH**
- Corneal Diameter
- Corneal Geometry
- Limbal Geometry
- Scleral Geometry

**CONTROL PARAMETERS**

**CORNEAL DIAMETER**
CORNEAL GEOMETRY

FOCAL GEOMETRIC CHANGES

DOES BASE CURVE AFFECT VAULT?

LIMBAL GEOMETRY

LIMBAL LENS DESIGN
LIMBAL CLEARANCE

PERIPHERAL LENS DESIGN
- Periphery
- Edge

OCULAR GEOMETRY
NASAL VS TEMPORAL

OCULAR GEOMETRY
SCLERAL TORICITY

EDGE
- Good alignment
WHAT DETERMINE THE RIGHT AMOUNT OF SAGITTAL DEPTH?

- Vision?
- Oxygen?
- Physiological Response?
- Disease State?

DOES SAGITTAL DEPTH AFFECT VISION?
DISEASE STATE

PHYSIOLOGICAL RESPONSE

CORNEAL EDEMA

ENDOTHELIUM

COMPRESSION ON AN INFLAMED EYE

SO HOW DO YOU DESIGN A LENS?
THE FIRST QUESTION YOU MUST ASK YOURSELF...

What Diameter am I going to use?

NOMENCLATURE

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Abbreviation</th>
<th>Name</th>
<th>Diameter</th>
<th>Bearing</th>
<th>Tear Reservoir Capacity</th>
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</thead>
<tbody>
<tr>
<td>Correct</td>
<td></td>
<td></td>
<td>8.0 to 12.5 mm</td>
<td>All lens bearing on the cornea</td>
<td>No tear reservoir capacity</td>
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<tr>
<td>Corneal</td>
<td>CCL, SCCL</td>
<td>Corneal Limbal Scleral Corneal Limbal</td>
<td>lens bearing on the cornea and the sclera</td>
<td>Limited tear reservoir capacity</td>
<td></td>
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<tr>
<td>Full Scleral</td>
<td>Haptic</td>
<td></td>
<td>15.0 mm</td>
<td>All lens bearing on the sclera</td>
<td>Somewhat limited tear reservoir capacity</td>
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<tr>
<td></td>
<td>Anterior</td>
<td></td>
<td>18.0 to 20.0 mm</td>
<td>Lenses on or near the sclera</td>
<td>Almost unlimited tear reservoir capacity</td>
</tr>
</tbody>
</table>

TOPOGRAPHY VS ELEVATION
MOVING THE FIT POINTS

- Point A is moved up or down by changing the overall SAG.
- Point B is moved up or down by changing the Base Curve.
- Point C is moved up or down by requesting more or less limbal clearance by microns.
- Point D is where lens lands on sclera, and so represents the reference point for moving the other fit points.
- Point E is moved up or down in 30 micron APS steps.

Each fit point can be moved individually, or in conjunction with one another.

CHANGES IS RADIUS AND WIDTH

WHERE TO BEGIN??

- Start with corneal diameter and general eye shape.
- If cornea is prolate in shape (steeper centrally) use the prolate design.
- If cornea is oblate in shape (flatter centrally) use oblate design.

CENTRAL VAULT

- If you want somewhere in between, just specify the sag you want.

CENTRAL VAULT

- Figure 1: Unacceptable central touch
- Figure 2: Central Clearance
- Figure 3: 4.600 SAG lens with roughly 200 microns of vault
- Figure 4: 4.600 SAG lens with roughly 900 microns of vault

Allen Optical
LIMBAL CLEARANCE

2) Limbal Clearance: The lens should also exhibit clearance beyond the limbus. If a lens does not demonstrate full limbal clearance, either move to a larger diameter or ask for an increased limbal clearance as a custom parameter when ordering.

Figure 5. Unacceptable limbal bearing
Figure 6. Clearance the extends beyond limbus with larger diameter lens

HOW DOES THIS AFFECT POWER?

- By adding a reverse curve
  - Flatter base curve = less minus
- A 60.00 cornea could have a 45.00 BC
- Therefore a -20.00 eye could wear a -5.00 lens
- This affects lens thickness and oxygen transmission
- Conversely, you may not want a flatter BC on a high hyperope.

COMPRESSION

SHADOWING OF THE LENS EDGE

- Easy way to assess the edges for excessive lift
- Position slit beam across lens and view the far lens edge

SHADOW AT 3/9 O’CLOCK

Dr Jason Jedlicka
ELEVATION SPECIFIC TECHNOLOGY

THE PENETRATING KERATOPLASTY

SPECIFIC INDICATIONS

- Keratoconus
- Aphakic corneal edema
- Psuedophakic corneal edema
- Failed graft
- Fuch's corneal dystrophy
- Herpes Simplex Keratopathy
- Inflammation
- Trauma
- Stromal dystrophies

PKP OBJECTIVES

1. Establish a clear central cornea/Visual axis
2. Minimize refractive error
3. Provide tectonic support
4. Alleviate pain
5. Eliminate infection

ASTIGMATISM: OPERATIVE FACTORS TO CONSIDER

1) Donor cornea
2) Recipient corneal disease
3) External compression factors
4) Trephination (host/ donor)
5) Tissue mal-apposition
6) IOP
7) Suturing
ASTIGMATISM:
POST-OP MANAGEMENT

- Intraoperative prevention
- Corneal topography
- Suture adjustment and/or removal
- Corneal Relaxing Incisions (CRIs or LRIs)
- Compression sutures
- Laser refractive surgery (ie. LASIK, PARK)
- Wedge resection
- Wound revision

SELECTIVE SUTURE REMOVAL

- Pre-removal
- Immed post-removal
- 2 week post-removal

CONTACT LENSES AND THE PKP

CONTACT LENS DESIGN

- Corneal Gas Permeable
  - Front toric
  - Back toric
  - Bitoric
  - Spherical
  - Diameter modification
  - Optic zone modification
  - Rotationally assymmetric
  - Reverse geometry

SOFT LENSES

- Choose:
  - Material: high Dk
  - Corneal hypoxia
  - Neovascularization
  - OAD: 2mm > HVID
  - BC: 0.5mm > flat K

CONTACT LENSES DESIGN

- Scleral lenses
  - Total corneal vault
SOFT LENSES

- Astigmatism
  - Avoid tight fit or thick lenses
  - May be difficult to get stability
- Piggyback with hyper Dk lenses
- Avoid extended wear
  - Risk of chronic edema, infection, neovascularization

INDENTIFYING CORNEAL GRAFTS TOPOGRAPHICALLY

- The perfect graft
- The plateau graft
- The proud graft
- The tilted graft
- The high cylinder graft

THE PERFECT GRAFT

- These are not the eyes that will be sent to you to be fit
- Every surgeon has a different definition of “perfect”
  - Usually 20/40 or better
  - Some consider success to be spherical equivalent within 2 D of emmetropia

THE PLATEAU GRAFT

- Tight stitches
- Low IOP
- Vitrectomy at the time of surgery
- Filter
- Button < 0.5mm larger than host
- Same size graft with KCN patients to get flattening (reduce myopia)
THE PLATEAU GRAFT

- Surgical correction
  - Need to keep chamber formed
  - Resuture
  - Remove running suture

THE PLATEAU GRAFT

- Contact Lens Correction
  - Standard design RGP would vault and trap excess tears and bubbles beneath the lens
  - Fit very small (within the graft)
  - Fit very large (reverse geometry)

THE PLATEAU GRAFT

- Small/flat lenses will ride high

THE PLATEAU GRAFT

- Central Bubble

THE PLATEAU GRAFT

- Good Plateau fit may need extreme curves
  - Graft host junction may be site for lens adherence

THE PLATEAU GRAFT

- Edge lift off

30.00BC with 8D reverse curve
THE PLATEAU GRAFT

• Large OAD
• Oblate design with large optic zone
  • vault running suture
• Fit PC’s separately

THE PROUD GRAFT

• The graft is evenly elevated above the host

THE PROUD GRAFT

• Small recipient bed or large donor button
• Tending to create pseudo-cone

THE PROUD GRAFT

• Surgical Correction
  • Resuture
  • Repeat PKP
  • PRK for anisometropia
    • Cannot cut flap
  • Epikeratophakia
THE PROUD GRAFT

- Difficult to fit periphery because of broad area of central elevation
- Need reverse curve to bring align periphery with host
  - Steeper
  - Longer

THE PROUD GRAFT

- Treat like a cone but may need large optic zone (instead of making OZ smaller)

THE TILTED GRAFT

- Without enough sag, usually get inferior lift off

THE TILTED GRAFT
**THE TILTED GRAFT**

- Usually seen in KCN/ PMD
- Tough to remove entire cone
- Trephine dependent
  - Use vacuum trephine to avoid undercutting
- Wound dehiscence
- Tissue mal-apposition
- Improper suture placement
- Unequal suture tension

**Surgical Methods to Correct**

- Pulling sutures
- Placing sutures
- Wedge resection
- Wound revision

**GRAFT TILT**

- Large lenses
  - Beware old grafts with poor endo function
- Small lenses
- Keratoconus designs
- Increasing or decreasing optic zone
- Assymetrical lenses

**ASSYMETRICAL LENSES**

- DL Flat/ Steep Lens
- Lens Dynamics

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**ASSYMETRICAL LENSES**

- DL Flat/ Steep Lens
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THE TILTED GRAFT
Large diameter lenses

HIGH CYLINDER GRAFT

Surgical Correction
- Selective suture removal
- Resuture
- Corneal relaxing incision
  - With or without compression sutures
- Refractive procedures
- Wedge resection
- Repeat PKP
- Refractive implant

HIGH CYLINDER GRAFT
- Causes
  - Elliptical opening
  - External compression
  - Cardinal suture placement/ tension

HIGH CYLINDER GRAFT
- Toric IOL
- 5 – 6 D cylinder common
HIGH CYLINDER GRAFT

- Contact Lens Options
  - Spherical lenses
  - Bitoric / Back toric
  - Large diameter lenses

INSIDE CYLINDER

- Periphery fairly spherical
- Spherical lens works well
- May be a proud cornea

OUTSIDE CYLINDER

- Lens will ride over highest/ steepest area
- May be a plateau cornea

PLATEAU WITH CYLINDER

FALSE CYLINDER

- Titled graft
- Proud graft
- Irregular astigmatism
- Remove sutures
KERATOCONUS

FITTING PHILOSOPHIES
• Three Point Touch
  • Apical bearing with mid-peripheral touch
  • Apical bearing 2-3mm wide
  • Advantage: vision may be better with flatter lenses
  • Disadvantage: Pressure on the apex may lead to erosions or scarring

FITTING PHILOSOPHIES
• Large diameter/flat lenses
  • Forced centration or pupil coverage
  • Good for large or inferior cones
  • Generally lid attached
  • Advantages: Good comfort, large optic zone, stays in eye when small lenses will not
  • Disadvantages: apical bearing, lower lid interaction

Small diameter lens Large diameter lens

TRADITIONAL KC DESIGNS

FITTING PHILOSOPHIES
• FDACL (First Definite Apical Clearance Lens - CLEK Study)
  • The flattest lens that vaults the apex of the cone
  • Start with initial lens equal to or steeper that average K and adjust BC until apical clearance is achieved.

Rose K 7.00 8.3 STD PC Rose K 6.60 8.3 STD PC

FITTING PHILOSOPHIES
• Reverse geometry
  • Steeper secondary curve position lens centrally and allows the base curve to vault, rather than touch, the cone.
  • Advantages: large optic zone, good centration
  • Disadvantage: lower lid interactions
REVERSE GEOMETRY DESIGN

TOO MUCH SAGITTAL DEPTH
- Central bubbles under the lens
- Lens rides low

NOT ENOUGH SAGITTAL DEPTH
- Lens decenters
- Touch over cone
- Bubbles at edge of lens

WHAT SHOULD YOU CONSIDER IN LENS DESIGN?
- Ease of fitting
  - Trial sets
  - Simple fitting guide
- Minimal fitting time
- High first fit success
- Minimal corneal insult
- Increased patient comfort
- Repeatable replacements

MANY DESIGN OPTIONS
- Apex Cone
- Comfort Cone
- Rose K
- Jupiter Cone
- Soper Cone

WHY DO YOU NEED MORE THAN ONE LENS DESIGN?
- Many types of cones!!
NIPPLE CONE
- Small, para-central cone
- Usually < 5 mm diameter
- Very steeply curved

SMALL CENTRAL CONES
- Traditional cone designs work well
- Many options

OVAL CONE
- Displaced apical center
- Inferior quadrant
- Cone diameter > 5-6 mm
TEMPORAL CONE

• Large diameter
• Larger optic zones
• Reverse Geometry

OVAL OR DISPLACED CONES

PELLUCID MARGINAL DEGENERATION

• “Kissing doves”
• Thinning 1-2mm from limbus

PSUEDO- PMD
PMD

- Reverse Geo lens
- Smaller lenses will ride low
- Often with inferior lift off

Scleral lens

GLOBUS CONE

- Largest
- Involves 75-90% of the cornea

FITTING A LENS

- Total Diameter
- Base Curve
- Peripheral Curves
- Power

DIAMETER

- Optimum:
  - Hang off top lid
  - Be well clear of lower limbus
  - Locate centrally

Central keratoconus – small diameter lens good fit

Animation courtesy of Lens Dynamics
FOR SMALL CENTRAL CONES

- Standard cone designs work well
- The steeper the cone the smaller the optic zone
- Generally smaller lenses
- However, diameter does not have to dictate optic zone

Inferior keratoconus – small diameter lens fits poorly

Animation courtesy of Lens Dynamics

Inferior keratoconus – large diameter lenses force centration

Animation courtesy of Lens Dynamics
BEST OPTIONS FOR INFERIOR CONES

- Small and Flat (low sag)
  - Will ride high
  - May have inferior lift off
- Large Diameter
  - Forced centration
  - Covers pupil better, less flare
  - Peripheral geometry of concern
  - More lower lid interaction
- Reverse Geometry

CHANGING DIAMETER

- Lower sag depth
  - 7.9
- Higher sag depth
  - 9.5

LID LOCATION

Post ptosis surgery

FITTING A LENS

- Total Diameter
- Base Curve
- Peripheral Curves
- Power

CHOOSING A BASE CURVE

- 3-4 mm Rule
- Yellow Rule
- Reference Sphere
- 2mm Flatter than Average K
- Fit steep K
3-4 MM RULE

- Temporal Quad

50.50D or 6.68mm

YELLOW RULE

59.00D or 5.72mm

.2MM FLATTER THAN AVERAGE K

Average K = 59.31
Or 5.7mm

57.00D or 5.9mm

REFERENCE SPHERE/ BFS

55.00D or 6.10mm

FIT STEEP K

Steep K = 61.37D

WHAT WORKS?

- Depends on type of cone
- Depends on type of lens
- Use the fitting set recommendation

- Remind patient that you are putting the first lens on the eye to get yourself orientated.
  - The patient won’t be able to see and the lens will likely be uncomfortable.
BASE CURVE SHOULD BE EVALUATED WITH THE LENS RIDING OVER THE CONE

FLAT LENSES (LOW SAG) RIDE HIGH, STEEP LENSES (HIGH SAG) RIDE LOW

EVALUATING THE BASE CURVE

POOLING AT BASE OF CONE

BUBBLES UNDER THE LENS

BUBBLES UNDER THE LENS
FITTING A LENS
- Total Diameter
- Base Curve
- Peripheral Curves
- Power

PERIPHERAL CURVES
- Flat PC’s
- Standard PC’s
- Steep PC’s

EDGE LIFT
- Most important factor for a comfortable fit.
- Ideal Edge Lift = fluorescein band width of 0.6 mm to 0.8 mm wide

DON’T TRY TO ADJUST PERIPHERAL CURVES BY CHANGING THE BASE CURVE

PERIPHERAL CURVE ADJUSTMENT

<table>
<thead>
<tr>
<th>Lens Type</th>
<th>Base Curve</th>
<th>Peripheral Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD PC’s</td>
<td>8.0</td>
<td>10.3</td>
</tr>
<tr>
<td>Flat PC’s</td>
<td>8.0</td>
<td>10.3</td>
</tr>
<tr>
<td>Naturalens</td>
<td>8.0</td>
<td>10.3</td>
</tr>
</tbody>
</table>

I Kone

<table>
<thead>
<tr>
<th>Base Curve</th>
<th>Peripheral Curve</th>
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<tbody>
<tr>
<td>50.00</td>
<td>9.6</td>
</tr>
<tr>
<td>53.00</td>
<td>9.6</td>
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Naturalens

<table>
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<th>Base Curve</th>
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</tr>
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<td>Flat PC’s</td>
</tr>
</tbody>
</table>
**ADHERENCE**

- Make peripheral curves flatter and wider
- Flatten BC
- Reduce the optic zone

**INFERIOR LIFT OFF**

- Increased OZ
- Steeper PC's

**PIGGY BACK**

- Riding High
  - Reduce diameter
  - Steepen base curve
  - Reduce edge lift
- Low Riding
  - Increase diameter
  - Flatten base curve
  - Increase edge lift

**Rotationally Assymetric Lenses**

*Zone 2 has a different radius than Zone 1*
*Zones 3 and 4 are transition zones for 162*
FITTING A LENS
- Total Diameter
- Base Curve
- Peripheral Curves
- Power

POWER
- Over scope
- Refine in +/- 0.50 & +/- 0.25 steps
- Final lens power = trial lens + over refraction
- vertex > 4.0 D over Rx

PEARLS
- Finish refraction with lights on.
- Reassure patient if VA is not optimum at initial fitting (tearing)
- VA often improves over first few weeks wear.
- Educate patient about VA expectations (night driving)

CORRECTION OF RESIDUAL ASTIGMATISM
- Over Spectacles
- Front Surface Toric
- Peripheral Toric
- Large Diameter
- Reverse Geometry

OVER SPECTACLES
- A/R coat
- Photochromic
- Prescription sunglasses
FRONT SURFACE TORIC

- Increase diameter 0.3 mm
- Incorporate prism ballast
- Truncation if required

SUMMARY

- Determine location of cone
  - Elevation maps helpful
  - Lens will center over "high" area
- Choose design and diameter of lens based on cone type.
  - Large lens for cone centration
  - Small lenses for central cones

SUMMARY

- Patients with PMD require large diameter, or even scleral, GP lenses.

SUMMARY

- Select base curve based on the fitting algorithm of your choice
- Place lens on eye and determine sagittal depth
  - Flat lenses ride high
  - Steep lenses ride low
  - Only evaluate overall sagittal depth with the lens centered on the cone

SAGITTAL DEPTH

- Decrease
  - Decrease diameter or optic zone
  - Flatten BC
  - Widen/flatten PC's

- Increase
  - Increase diameter or Optic Zone
  - Steepen BC
  - Narrow/steep PC's

SUMMARY

- Diameter/OZ
  - Optimize centration
  - Minimize lid interaction
  - Increase diameter: increase sag
  - Decrease diameter: decrease sag
SUMMARY

- Base Curve
  - Greatest effect on sagittal depth
  - B/C changes do not adjust peripheral curves
  - Gracing touch over cone

SUMMARY

- Peripheral curves and edge lift
  - Effects comfort
  - Determine appropriate PC’s after the diameter and base curve have been selected
  - Alter diameter and base curve before doing quadrant specific designs

MOST IMPORTANTLY

- Don’t make too many changes all at once
  - Large fitting sets are helpful
  - Practice altering once parameter at a time to learn how each change impacts the overall fit
  - Remember, these are general principles and each lens will have its own specific nuances.

THANK YOU