Misconceptions and Misinterpretations in Corneal Topography

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Surface Representations

- Axial
  - Average representation of surface curvature
- Tangential (also Meridional)
  - Local representation of surface curvature
- Elevation
  - Relative to a reference
- Optical (Snell) Power (also Refractive)
  - Image formation

Misconceptions

- Topography vs Wavefront
- Elevation vs Curvature
- Axial vs Tangential Curvature
- Power vs Curvature
- “Bumps” on a Posterior Power Map?

Why do I need Corneal Topography when Wavefront Analysis Measures the Entire Eye?

Because Refractive Surgery Alters the CORNEA!

100% of Induced Aberrations are from the CORNEA!
Wavefront vs Topography

Wavefront tells you the origin and destination

Shape (topography) tells you the mechanism

Wavefront cannot provide the location of an aberration-producing feature

Example: COMA

Is the origin of 3rd order coma a central or peripheral feature?

Coma is nonspecific

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Elevation

• Anterior or Posterior Surface

• Requires a Reference
  – Relative height
  – Can be compared to a plane
  – Can be compared to a sphere
  – Can be compared to an asphere

• “Best-fit” sphere is most often chosen

Why Does BFS Vary in Same Patient?

• Depends on the Region over which the BFS is Fit!
  – On a normal eye, the smaller the region, the greater curvature of the BFS since corneas tend to have greater curvature in the center

• If missing data are different from exam to exam, then data used for calculation are different and BFS will also be different
Height relative to a plane reference

What conditions?

Plane Reference

Best-Fit Sphere Reference

Elevation relative to “Best-Fit” Sphere

- Central “High” point
  - Steeper than the sphere
- Peripheral “High” point
  - Flatter than the sphere
- Central “low” point (negative number)
  - Flatter than the sphere — NOT A CONCAVITY still highest spot on cornea
- Peripheral “low” point
  - Steeper than the sphere
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Refractive Power

• Incoming light rays are refracted by the first surface
• The angle of refraction is dependent on the incoming angle of incidence

Power vs Curvature for a Sphere and two Ellipses

Optical power
Axial dipters
Tangential Curvature

Power and Curvature are directly proportional

Total Corneal Power derived from anterior and posterior corneal surfaces

• Ray Tracing through BOTH surfaces
  – Snell’s Law Refraction:

Optical power
Axial dipters
Tangential Curvature

Power and Curvature are directly proportional

ONLY in the central paraxial region

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Retrospective Study of Post-Op Shape

- 2,380 myopic LASIK patients with pre-op and 6 month post-op Orbscan Topography
- Technolas 217 excimer laser
  - “Optical Zone” sizes from 5.0 to 6.5mm diameter
  - Transition zones extended to 9mm diameter
- Hansatome or Automated Corneal Shaper Microkeratome
- Collaborators: Dr. John Chang and the refractive surgery team of the Hong Kong Sanatorium and Hospital

Average Posterior Difference Maps for Entire Population

- n = 2,380
- All regions show statistically significant differences from pre-operative state.

Average Posterior Difference Maps Myopic Correction < 2 Diopters

- n = 25
- For elevation and tangential curvature, only the intermediate regions were significantly different from pre-op

Average Posterior Difference Maps Myopic Correction from 2 to 4 D

- n = 321
- All regions except inner elevation and intermediate axial zones show statistically significant differences from pre-operative state.

Average Posterior Difference Maps Myopic Correction from 4 to 6 D

- n = 635
- All regions show statistically significant differences from pre-operative state.

Average Posterior Difference Maps Myopic Correction from 6 to 8 D

- n = 622
- All regions show statistically significant differences from pre-operative state.
Average Posterior Difference Maps
Myopic Correction from 8 to 10 D

- n = 465
- All regions show statistically significant differences from pre-operative state.

Data acquired at the Hong Kong Sanatorium and Hospital

Average Posterior Difference Maps
Myopic Correction for > 10 Diopters

- n = 311
- All regions except outer pachymetry zone show statistically significant differences from pre-operative state.

Data acquired at the Hong Kong Sanatorium and Hospital

Interpretation of Increased Posterior Curvature after Refractive Surgery

- 3 models of increased posterior curvature were compared with actual patient posterior topography
- 2,380 patients with pre-op and 6 month post-op Orbscan topography (Hong Kong Sanatorium and Hospital)
- Pre-op subtracted from corresponding post-op, and all difference maps averaged for each of 3 fitting protocols

Central Decompensation?

Forward Vault?

Inward Peripheral Movement?
How would these surfaces appear if fit and subtracted?

It depends on the fitting protocol used!!

Pre and Post-Op Surfaces Fit over Entire Region of Interest

• Most common default of the Orbscan
• Surfaces fit above and below each other

Pre and Post-Op Surfaces Fit over Entire Region of Interest

• Average difference map of 2380 LASIK patients
• Similar pattern to all models, as predicted!

Apex Fit of Pre and Post-Op Surfaces

• Post-op surface fits “below” pre-op for all models

Apex Fit of Pre and Post-Op Surfaces

• Average difference map of 2380 LASIK patients
• Similar to all!

Peripheral Fit of Pre and Post-Op Surfaces

• If forward movement, post-op should fit “above” pre-op
• If backward movement, post-op should fit “below” pre-op in periphery
Peripheral Fit of Pre and Post-Op Surfaces

- Average difference map of 2380 LASIK patients
- Consistent with backward movement model!

Posterior Surface

Patient Data is consistent with Peripheral Inward Movement, NOT outward central movement!!

Stable Remodeling!!!!!!!!

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Curvature

Axial vs Tangential: Normal Eye

Keratoconus

Axial
Tangential
**PRK**

Axial vs Tangential

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**Decentered Ablation?**

Axial vs Tangential

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**Contact Lens Warpage**

Axial vs Tangential

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**Axial (A₁ and A₂) vs Tangential (C₁ and C₂)**

Reference Axis

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The location of the greatest curvature is more stable on a Tangential map, as the Center of the Map is moved.
Axial vs Tangential Curvature

- Advantages
  - Axial: global indication of corneal shape
  - Tangential: details of corneal shape

- Disadvantages
  - Axial: miss important details
  - Tangential: noisy

NEITHER ONE IS POWER!!

Summary

- Topography is shape and Wavefront is function
- High resolution is required to calculate curvature from elevation
- Tangential Curvature represents local shape and Axial Curvature represents global shape.
- Refractive or Optical Power represents image formation and curvature labeled in diopters is NOT power.
- A red spot on the posterior surface does NOT always mean ectasia.
- The terms “Oblate” and “Prolate” are not meaningful on a post-LASIK cornea
- BE CAREFUL when you read the literature!