Reliability of corneal first-surface wavefront aberrations measured with the Oculus Pentacam

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Background

- 2006 Wavefront Congress, Bahamas
- Pesudovs K, Sarver EJ. Wavefront aberrations arising at the posterior corneal surface in normal and diseased eyes.
- Sensible posterior corneal wavefront aberration magnitudes
- Larger than expected anterior corneal wavefront aberration magnitudes
Geunyoung Yoon

Question: Have you looked at repeatability of wavefront aberrations derived from the Oculus Pentacam?
Purpose

To assess the reliability of corneal first surface wavefront aberrations (WFAs) derived from Oculus Pentacam corneal topography

In normal and diseased (keratoconus) eyes
Methods

- Corneal topography was taken with the Oculus Pentacam rotating Scheimpflug camera system.
- Cross-section of anterior segment
- Rotates – 25 sections in 2 seconds
Oculus Pentacam
Oculus Pentacam

- Chin rest and forehead strap
- Images taken by “auto-capture”
- 4-8 seconds post-blink
- Scans only accepted if registered as "OK" on the instrument’s “Examination Quality Specification”
- 0.6 mm decentration
Population - Normal

- Recruited subjects from patients attending the eye clinic and Flinders Medical Centre, staff and friends
- 3 populations: 2 normal, 1 disease
- Population 1: 10 normal individuals, 20 eyes (6 male and 4 female, aged 39.0 ± 5.4 years)
- Population 2: 35 normal individuals, 70 eyes (19 female, aged 35.5 ± 14.8 years)
Population - Keratoconus

Population 3: 10 people with keratoconus, 14 eyes (6 female; mean age 41±16 years, age range 30–57 years)

Keratoconus grading by the CLEK study grading system – mild (<45), moderate (45–52 D) and severe (>52 D)

6 eyes had mild, 5 eyes moderate and 3 eyes had severe keratoconus
Experiment Design - Normals

Population 1: tested on 2 occasions by 3 observers who took 2 measurements each
Population 2: tested on 1 occasion by 2 observers who took 1 measurement each
120 comparisons for within session intra observer reliability, 240 comparisons for between session intra observer reliability, 240 comparisons for within session inter observer reliability and 480 comparisons for between session inter observer reliability
Experiment Design - Keratoconus

- Population 3: tested on 1 occasion by 2 observers who took 1 measurement each
- 14 inter-observer comparisons
Analysis

Ed Sarver developed the code to calculate posterior corneal surface aberrations from Pentacam data

Topography data exported to VOLPro software v7.08 (Sarver and Associates)

10th order Zernike expansion derived for a 6.0mm pupil

Corneal refractive index 1.376
Analysis

- Reliability was determined with Bland-Altman limits of agreement
- Expressed as the coefficient of repeatability (COR=±1.96 standard deviation of the differences)
- Also expressed as relative repeatability (% of ratio of COR to mean)
- Differences between groups tested with ANOVA and post hoc (Sheffé) testing (p<0.003)
Results

Patient Demographics

Age

<table>
<thead>
<tr>
<th>Population</th>
<th>Normal1</th>
<th>Normal2</th>
<th>Keratoconus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Male</td>
<td>□</td>
<td>□</td>
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</tr>
</tbody>
</table>
Results - orders
Results - modes

COMPARISON OF MEAN WFA's

Populations

Mean WFA's

Differences between populations:
- Normal 1
- Normal 2
- Keratoconus

Types of WFA:
- Trefoil
- Coma
- Tetrafoil
- Pentafoil
- 2nd astigmatism
- Hexafoil
- 2nd trefoil

Comparison of modes in different populations.
Results - repeatability

COMPARISON OF INTRA AND INTER OBSERVER COR FOR ZERNIKE ORDERS

- Intra observer Same day COR
- Inter observer Same day COR
- Intra observer Between days COR
- Inter observer Between days COR

- total HO RMS
- 3rd order
- 4th order
- 5th order
- 6th order
- 7th order
- 8th order
- 9th order
- 10th order
Results - repeatability
Results – relative repeatability

Comparison of Cor and Mean WFA for Normal Population 2
Results – relative repeatability
Results – Keratoconus

Comparison of COR and Mean WFA for Keratoconus Group

Zernike coefficients

- Trefoil
- Coma
- Tetrafoil
- Pentafoil
- 2nd astigmatism
- 2nd trefoil
- 2nd coma
- Hexafoil
- 2nd tetrafoil
- 3rd astigmatism
- Total HO RMS
- 3rd order
- 4th order
- 5th order
- 6th order
- 7th order
- 8th order
- 9th order
- 10th order
Discussion

WFAs were remarkably large in magnitude.

Reliability is poor in both normal and keratoconus populations.

Intra and inter observer reliability both within session and between sessions were all comparable.

 Likely due to automated capture.
Discussion

- Reliability worse for individual modes, better for orders – averaging
- Implies noise in the measurement
- Averaging multiple measurements?
- Centration, alignment and movement
- Noise amplification in the calculation
Suggestions or questions?

THANK YOU