Scheimpflug-based lens densitometry in the preoperative assessment of age-related nuclear cataracts

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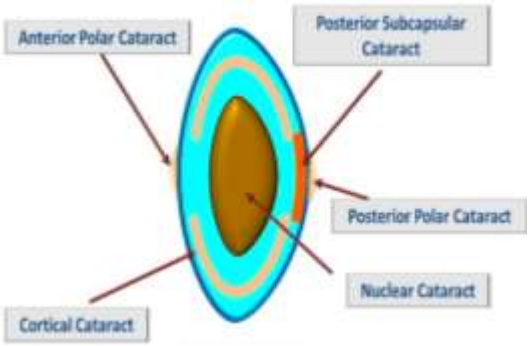
Cataract

- Opacity of the crystalline lens
- Distinct classifications
  - Anatomical location
- **Age-related nuclear cataracts**
  - Multifactorial interactions
  - **Degenerative** changes in the lens



- Increase of water insoluble proteins in the crystalline lens
- Hardening of the lens (lose of elasticity)
- Electrolyte imbalance that leads to hydration of the lens
- Changes in lens epithelial cells (altered metabolism)
- Less protective effect against oxygen stress (reduction of glutathione, e.g.)

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Ancillary Tests for Cataract Evaluation

- Standardized clinical grading and photographic systems (comparing a patient's cataract with standard photographs)
  - Lens Opacities Classification System (LOCS) III Grading system
  - Wisconsin Clinical and Photographic Cataract Grading system
  - Wilmer Clinical and Photographic Cataract Grading system
  - Oxford Clinical Cataract Grading system
  - Age-Related Eye Disease Study (AREDS) Cataract Grading System
- Scheimpflug imaging
- Optical coherence tomography
- Ultra-high frequency ultrasound
- Wavefront sensors
- Autofluorescence

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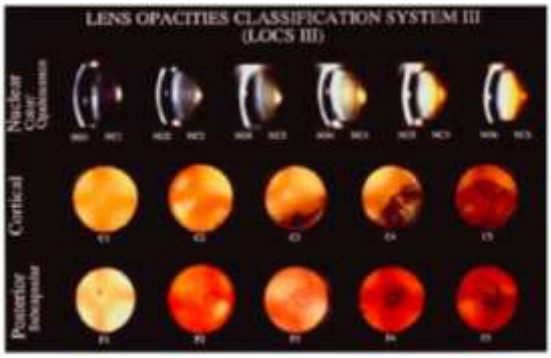
LOCS III

- The **Lens Opacities Classification System III** (LOCS III; validated in 1993) is a subjective scoring method based on **slit-lamp/photography examination**, which rates a cataract depending:
  - **anatomical location** (nuclear, cortical, posterior subcapsular);
  - grade of the **opacity/color**.



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Scheimpflug Principle

Clinical applications of the Scheimpflug principle in Ophthalmology

Aplicações clínicas do princípio de Scheimpflug na Oftalmologia

- **Advantages:**
  - extends the **depth of focus**
  - more **sharpness** to points of the image located at different planes
  - **minor distortion** of the image

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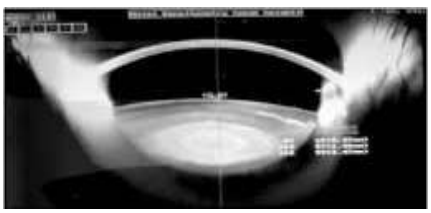
Scheimpflug Imaging in Cataract

Nidek EAS 1000 (Gamagori, Japan)

- Introduced in the 90's
- First devices incorporating Scheimpflug Principle (**horizontal scan**);
- Ability to detect **changes in lens transparency** over time;



These systems, however, did **not perform tomographic three-dimensional reconstruction** of the cornea and anterior segment.

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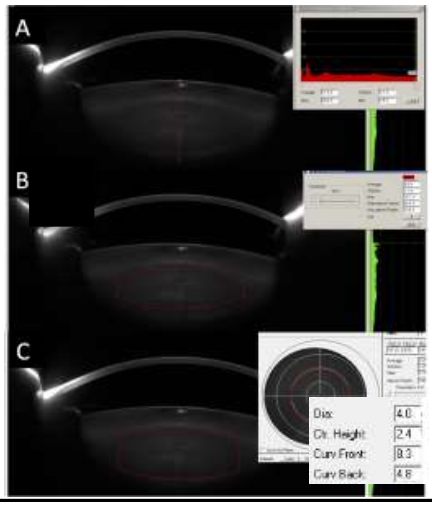
ARTICLE

Repeatability of lens densitometry using Scheimpflug imaging

Xenia Weiner, MD, Martin Baumeister, MD, Thomas Kohnen, MD, PhD, FEBO, Jens Bühren, MD

J Cataract Refract Surg 2014; 40:756–763 © 2014 ASCRS and ESCRS



Despite to provide more precise and reliable measurements compared to the LOCS III grading system

Literature review shows a **variety of approaches** and **results regarding the Scheimpflug-based lens densitometry evaluation**.

Affects the scientific and clinical conclusions of the research studies.

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Introduction

Scheimpflug-based lens densitometry

ARTICLE

Repeatability of lens densitometry using Scheimpflug imaging

Xenia Weiner, MD, Martin Baumeister, MD, Thomas Kohnen, MD, PhD, FEBO, Jens Bühren, MD

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The dilemma of decreasing repeatability against more individual information has not been solved. Although the peak mode showed a satisfactory CoR, the maximum opacification value should be involved in the analysis of lens densitometry. Still, a suitable metric that might combine parameters has to be defined.

Studies have approached this problem in several ways. While Kirkwood et al.[6] and we examined different opacification values computed by Pentacam software, Pei et al.[7] restricted their analysis to the peak value. Grewal et al.[8] chose an elliptical ROI, which excludes the lens cortex and is set within the nuclear opacification zone to avoid the zone of discontinuity surrounding the nucleus. Also, Kim et al.[9] defined an elliptical ROI whose mean density and maximum density were measured.

The multitude of approaches reflects that there is no absolute solution to define the ROI, which impedes comparability of densitometry values. It remains to be determined whether the application of an individual, but repeatable ROI could be defined consistently to enable comparable measurements for scientific and clinical purposes.

Despite these issues, standardized and objective assessment of cataract with Scheimpflug imaging offers a considerable opportunity for multiple scientific and clinical purposes. A clinically and economically interesting application of Scheimpflug imaging could be its use before phacoemulsification.

Another topic for research of Scheimpflug imaging is the possible relationship between increasing age-related lens opacification and the progressive loss of function of the lens; that is, presbyopia.

The heterogeneity of the results suggests that for different purposes (eg, prediction of functional impairment versus intraoperative lens parameters), different metrics may be needed. As a next step, the correlation of densitometry with functional parameters is necessary. A study addressing this issue is underway.

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ARTICLE

Scheimpflug lens densitometry and ocular wavefront aberrations in patients with mild nuclear cataract

Fernando Faria-Correia, MD, Bernardo Lopes, MD, Tiago Monteiro, MD, Nuno Franqueira, MD, Renato Ambrósio Jr, MD, PhD

J Cataract Refract Surg 2016; 42:405–411 © 2016 ASCRS and ESCRS

- **Forty eyes** of 30 patients with **mild nuclear cataract** were included in this study.
- LOCS III Nuclear Opalescence (NO) grade:
  - 2 eyes with grade 1
  - 7 eyes with grade 1.5
  - 15 eyes with grade 2
  - 8 eyes with grade 2.5
  - 8 eyes with grade 3

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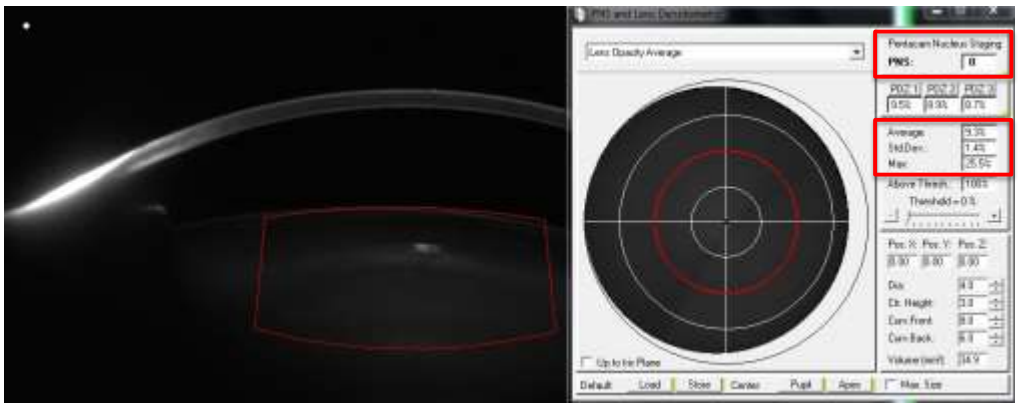
Correlation between Scheimpflug optical densitometry and HOAs in patients with mild nuclear cataract

Pentacam Nuclear Staging (PNS) software allows **objective quantification** of lens opacities inside of a **cylindrical** template:

- **average density** and **maximum density** parameters on a continuous scale from 0 to 100 %;
- lens opacity grade (**PNS score**) on a scale from 0 to 5.



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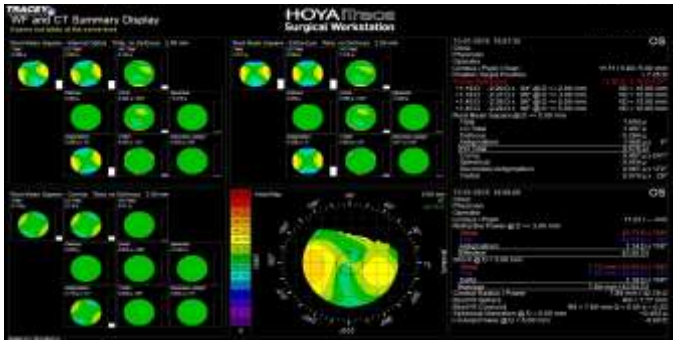
- Wavefront sensor (principle of **optical ray tracing**) combined with Placido-disc topography
- **256 near-infrared** laser beams to measure forward aberrations, processing data point-by-point.



- **Total ocular and internal HOAs** were registered.

Correlation between Scheimpflug optical densitometry and HOAs in patients with mild nuclear cataract

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RESULTS

- **Age** was positively correlated with:
  - LOCS III NO score (rho = 0.364, P = .023),
  - PNS score (rho = 0.518, P = .001),
  - **Average density (r = 0.767, P < .001)**,
  - Maximum density (r = 0.401, P = .010).

- **CDVA** was correlated with the:
  - LOCS III NO score (rho = 0.339, P = .034),
  - PNS score (rho = 0.453, P = .005),
  - **Average density (r = 0.744, P < .001),**
  - Maximum density (r = 0.408, P = .003).

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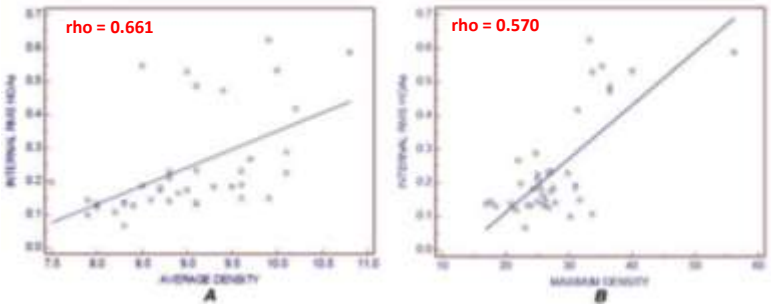
Correlation between Scheimpflug optical densitometry and HOAs in patients with mild nuclear cataract

RESULTS

Significant positive linear correlations were found between the average and maximum density parameters and the internal HOAs (rho = 0.661, P < .001; rho = 0.570, P < .001, respectively).



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Clinical Ophthalmology
Dovepress
ORIGINAL RESEARCH

Application of different Scheimpflug-based lens densitometry methods in phacodynamics prediction

Clinical Ophthalmology 2016:10 609–615

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Renato Ambrósio Jr[3-6]

- 50 eyes included in the study (30 women and 20 men).
- Mean age of the patients was 71.52±7.71 years (range: 57 to 75 years).
- LOCS III Nuclear Opalescence grade:
  - 4 eyes with grade 1
  - 15 eyes with grade 2
  - 15 eyes with grade 3
  - 16 eyes with grade 4

Table 1. Densitometric data provided by the different evaluation methods

	Range	Mean ± SD
Nuclear Opalescence	1.0 – 4.0	2.88 ± 1.02
Linear Average Density	7.9 – 11.9	9.69 ± 0.96
Linear Maximum Density	9.8 – 29.8	17.61 ± 4.90
ROI Average Density	6.3 – 11.4	8.46 ± 0.87
ROI Maximum Density	6.2 – 19.2	12.11 ± 2.63
3D Average Density	6.3 – 11.4	8.46 ± 0.90
3D Maximum Density	6.2 – 16.0	11.97 ± 2.23

ROI = Region of interest
3D = Three dimensional

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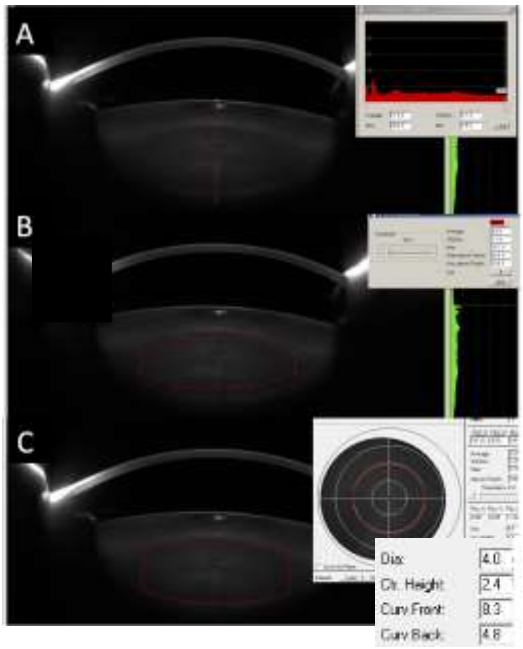

- Different methods of **lens densitometry evaluation** (**absolute scale from 0 to 100%**): linear (A), region of interest (ROI; B) and three-dimensional (3D; C).
- **Average density** and **maximum density** parameters (on a continuous scale from 0 to 100 %).
- **Cumulative dissipated energy** (**CDE**) and **total ultrasound** (**US**) **time** were recorded after uneventful cataract surgery (stop-chop technique).

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Table 2. Correlation coefficients between nuclear opalescence and the quantification parameters derived from the different densitometry methods

	Nuclear Opalescence	
	Correlation Coefficient	p value
Linear Average Density	0.569	< .001
Linear Maximum Density	0.045*	.766
ROI Average Density	0.600	< .001
ROI Maximum Density	0.642	< .001
3D Average Density	0.624	< .001
3D Maximum Density	0.619	< .001

ROI = Region of interest
3D = Three dimensional
* Spearman correlation coefficient

- **A positive correlation** was detected between the **NO score** and the average density and the maximum density derived from the **3D** mode (r = 0.624, $p < .001$; r = 0.619, $p < .001$, respectively) and **ROI** mode (r = 0.600, $p < .001$; r = 0.642, $p < .001$, respectively).
- Regarding the **linear** mode, only the average density parameter presented a significant relationship with the NO score (r = 0.569, $p < .001$).

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Table 3 – Spearman correlation coefficients between the phacoemulsification parameters and the different evaluation methods

	CDE		Total US time	
	Correlation Coefficient	p value	Correlation Coefficient	p value
Nuclear Opalescence	0.414	.004	0.481	< .001
Linear Average Density	0.522	< .001	0.450	< .001
Linear Maximum Density	0.024	.871	0.044	.722
ROI Average Density	0.686	< .001	0.642	< .001
ROI Maximum Density	0.598	< .001	0.644	< .001
3D Average Density	0.682	< .001	0.631	< .001
3D Maximum Density	0.683	< .001	0.668	< .001

CDE = Cumulative dissipated energy
US = Ultrasound
ROI = Region of interest
3D = Three-dimensional

Bonferroni adjustment was used to lower the chance of a statistically significant difference based on chance alone. Thus, the *P* value must be **less than .004** to be considered statistically significant.

- Maximum density parameter derived from the linear mode did not present a significant relationship with both phacoemulsification metrics.
- **3D** and **ROI** average density and maximum density were positively correlated with **CDE** and **total US time**.

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Scheimpflug-based lens densitometry in the preoperative assessment of age-related nuclear cataracts

- Objective parameters from Scheimpflug densitometry had a strong correlation with:
  - age,
  - DCVA reduction,
  - NO,
  - Internal HOAs by ray-tracing aberrometry.
- Caution should be taken when using maximum density from the linear mode for lens densitometry assessment.
- Regarding the ROI and 3D modes, both average density and maximum density parameters presented a significant relationship with the LOCS III NO score and phacoemulsification parameters.

Thank you for your attention!

Cairo (Egypt) – 25/01/2018