Studies for Pseudophakia on Straylight, a Quality of Vision Parameter

Tom van den Berg, physicist

Netherlands Institute for Neuroscience
Royal Netherlands Academy of Arts and Sciences
t.j.vandenberg@nin.knaw.nl
www.herseninstituut.knaw.nl/straylightlab
c.r. disclosure

Royal Netherlands Academy of Arts and Sciences owns patent on the Compensation Comparison method for straylight measurement licensed to Oculus GmbH for the C-Quant instrument
Introduction

Function indicators for cataract surgery

Subjective:
patient, surgeon
Patient questionnaire highly unreliable on individual basis.
Only around 10% of functional variance explained:
Steinberg et al. 1994, Lundstrom and Pesudovs 2009, van der Meulen et al. 2012, etc.

Objective:
Visual acuity, gold standard (but confounded with refraction, and retinal condition. Better: aberrometry based (Applegate, Thibos, Watson))
Straylight (not confounded with refraction, nor retinal condition)

Straylight effects in pseudophakia
if added to VA as indicator for cataract surgery
large angle light spreading (straylight) versus small angle effects (aberrations, double pass image)
The Point Spread Function (PSF)

Visual acuity
1 min of arc
⇒ 0.02°

Contrast sensitivity
18..3 cycl/degree
⇒ 0.06..0.33°

Straylight
⇒ >1°

CIE 1999 standard
Caucasian/normal/average/50y

Ophthalmic and Physiological Optics 29 (2009) 345-350

Graphics by Ralph Michael
Objective assessment of straylight

Establish identity between the observed light and a reference light of known value

*psychophysics*
Psychophysical method “Compensation Comparison”

Van den Berg, Coppens, Franssen
ARVO 2005

characteristics

- International visual photometric principle (CIE)
- Bipartite field comparison of straylight to comparison light
- Functional value: straylight parameter “s”, given as log(s) (compare logMAR)
- Estimation of individual measurement reliability
Testing the psychophysical method using scatter models of known value

7 scatter models
4 subjects

Examples of scatter models
accurate assessment of straylight in patients possible

Ophthalmic and Physiological Optics 29 (2009) 345-350
In vitro straylight measurement
Łabuz et al. Biomed. Optics Exp. 2015

Exposure sample (IOL)

Cuvette with light scattering sample (IOL)

Observer
Sees only bipartite field
How does straylight compare to visual acuity?

Relation complaint $\Leftrightarrow$ Straylight

Simulations of patient vision for typical early cataract values
“hazy vision”

signs in our institute’s elevator

visual acuity 0.4 decimal

average normal eye

straylight 2x increased
against-the-light face recognition

visual acuity 0.4 decimal

average normal eye

increased straylight log(s)=1.4
upcoming headlights while driving at night

average normal eye

visual acuity 0.4 decimal

increased straylight
log(s) = 1.47
Subjective comparison of straylight and visual acuity

Questionnaire study in an (early) cataract population

(Van der Meulen et al. JCRS 2012;38:840-848)

VFQ (37 questions; Mangione et al. NEI version 2000) and 5 Straylight focused questions (SLQ)

217 pre-op cataract patients
Typical questions in the questionnaires (simplified)

How difficult is it to read a newspaper?

How difficult is it to judge facial expression, because of your vision?

How difficult is it to check your clothing, because of your vision?

How difficult is it to drive a car during daytime in your own neighborhood, because of your vision?

How strong do you experience blinding while driving a car at night.

Scoring on a 5-point scale, from very bad, to no problem at all, transformed into average scales from 0 – 100.
VFQ contains 37 questions, SLQ 5 questions
correlation results questionnaire outcomes
Van der Meulen et al. JCRS2012;38:840-848

Straylight and VA contribute in an approximate 1:1 relation
Population values

the normal eye
lens aging/cataract formation

(quality assessment in refractive surgery, corneal dystrophies, dry eyes, albinism, vitreous turbidity, .... )
Straylight increase with aging and cataract formation

Orange symbols cataract surgery study. JCRS 2012 38:840-848.
Straylight compared to visual acuity.
Orange symbols cataract surgery study. JCRS 2012 38:840-848.
Does cataract surgery help against straylight?

If so, what is the break-even point?

Or

what straylight level is to be expected in pseudophakia?
Straylight pre- and post routine cataract surgery
Straylight improvement factor 3.24 (sd 2.3)
(Visual acuity improvement factor 1.74 (sd 1.4))

95% chance of improvement
(309 cataract surgeries)

Oculus C-Quant
Only in a limited number of cases does straylight return to the young healthy reference level. In most cases straylight much better than the phakic best-eyes norm. Age effect on pseudophakic straylight.
Refractive surgery center; Lapid et al. submitted 2013; 160 lens exchange surgeries on good VA eyes (logMAR<0.1).

Same finding; in limited number of cases does straylight return to the young healthy reference level. In most cases postop straylight better than the phakic norm for best eyes. Age effect.
The mean straylight value (± SD) for 1,869 eyes is 1.21 (± 0.21) log(s) with mean age 68 (± 9) years.

Linear model of straylight-age dependency for 13 articles (lines). Line extent gives the age range. For 3 studies the regression line was not obtainable. The diamonds represent the centers of gravity of the 16 individual datasets.
Predictability of improvement upon CE

The 558 available pre- and postoperative records were analyzed to assess the Break Even Point (BEP) for pre-operative straylight (to achieve improvement).

Improvement of straylight upon crystalline lens exchange. The diamonds indicate the BEP of the different age groups.
Selected studies on IOLs

IOL deposits and calcification

A Rayner
B Hydroview
C Aquasense
Mrs W., age 72 years
Vision complaints not corresponding VA.
Extreme straylight Log(s) = 2.22 (20x)
Deposit on IOL
Study eye lens: Hydroview B&L

Clinically opacified
Around 5 x increased straylight (VA 25% loss)

“Clear” (not slitlamp detected)
Around 2 x increased straylight (VA no loss)

Blundell, Knox Cartwright et al ARVO 2009, BJO 2010
Straylight from 2 explanted calcified Aquasense lenses

Diffractive multifocal

The edges of diffractive profiles scatter light
Straylight values 6 months after cataract surgery.

Multifocals give more straylight than monofocals

De Vries, Nuijts, Tjia, et al. JCRS 2008

Straylight values 6 months after cataract surgery. Multifocals give more straylight than monofocals.
Comparison between diffractive multifocals
Łabuz et al. JCRS 2016 in press

Hydrophobic multifocal IOLs give more straylight (p=0.001)
Glistenings
6 eyes
straylight from glistenings
compared to total straylight
lines indicate fraction of total
(100%, 50%, 20%)

In some cases may glistenings contribute significantly to straylight.
Large angle light spreading and visual acuity

normal eye

(Extreme) straylight
Summary

Straylight measurement in vivo according international standard

Also possible in vitro, on IOLs, directly comparable to the clinical straylight measurement

Cataract surgery is efficient to reduce straylight, but room for improvement

Straylight from IOL associated problems can be considerable

Straylight to be considered in IOL design
THANKS