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INTRAOCULAR STRAYLIGHT AND CONTRAST SENSITIVITY TWO MONTHS AFTER LASIK*: Intraocular straylight measurement as a new parameter in visual quality assessment*

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INTRODUCTION

Vision is defined as the faculty or state of being able to see. Vision, as every other body function, is a very complex process that involves many organs and systems, including of course, the brain. Our brain is the command centre of our body. Each and every external or internal stimulus that is perceived by the different neuroreceptors of the peripheral nervous system is sent to the brain, where the neuronal interactions can make us feel that stimulus. That perception can be either physical of psychical. Is the integration of the peripheral and central nervous system what let us be able to feel pain when we get hit, warm when we are exposed to heat, recognize a familiar scent and recognize a person's face when we see them. Every type of neuroreceptor in our body needs a specific stimulus so it can send the information to the brain.

Light stimulus is needed for vision. For this, light has to pass through many tissue layers to get to its specific neuroreceptor. After light is reflected over the surface of the object that is being viewed it reaches the eye and has to travel across all the transparent optical media of the eye: tear film, cornea, aqueous humour, crystalline lens, and vitreous gel (figure 1). Every one of these layers has their own surface curvature and different refractive index. When light has finally crossed all these layers, it is absorbed by the retina, the receptor organ, where an array of photoreceptors is responsible for converting the light stimulus into an electrical impulse (figure 2).

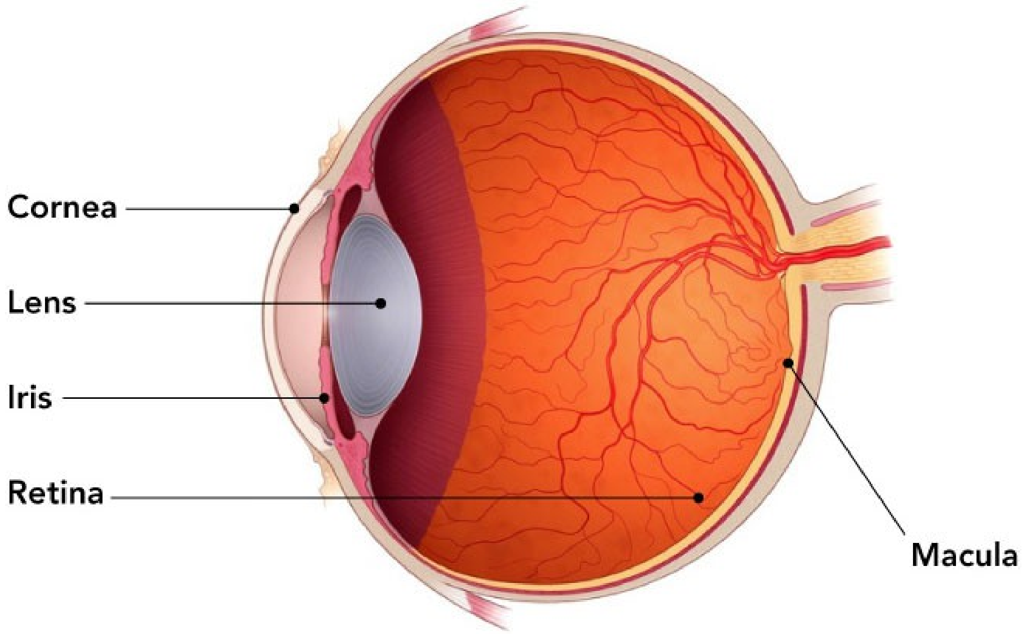

Figure 1. Light reflected from the viewed imaged travels across the transparent optical media of the eye until it reaches the retina.

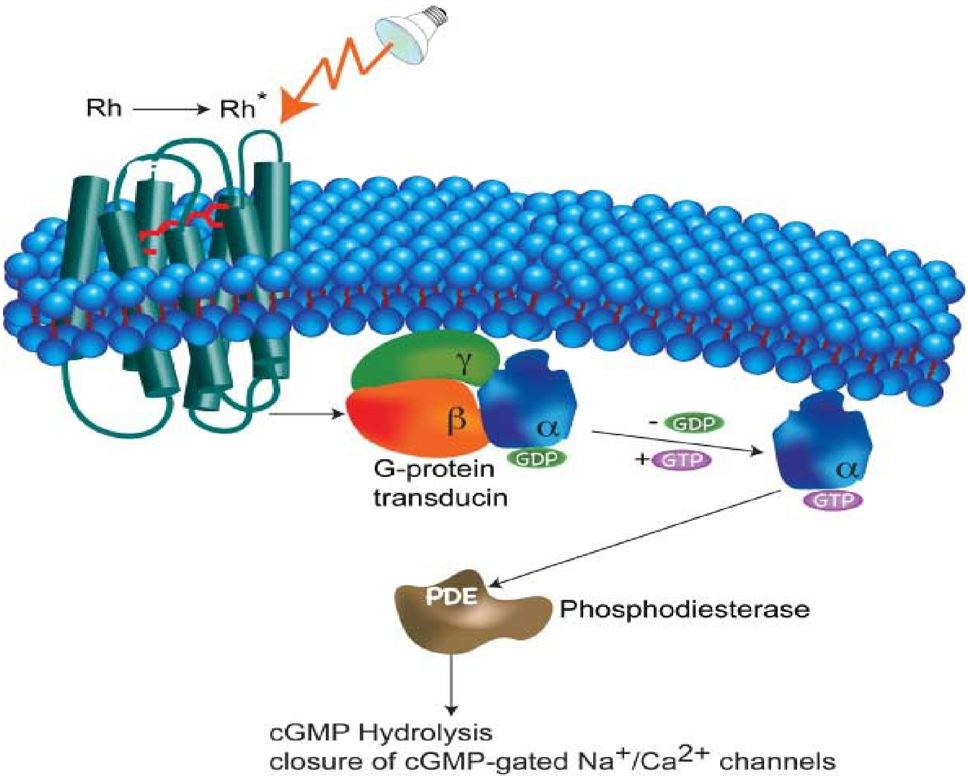

Figure 2. Photoreceptors on the retina transform light stimulus into electrical impulses by special proteins.

These specialized neuroreceptors are the cones and rods. They respond to different levels of light intensity (figure 3). Moreover, cones respond to different wavelengths, allowing us to see different colours. After all those different stimuli are phototransductued, they are conducted through the optical nerves until they reach the visual cortex in the occipital lobe of the brain, a specialized area where this information is processed and the image is formed (figure 4).

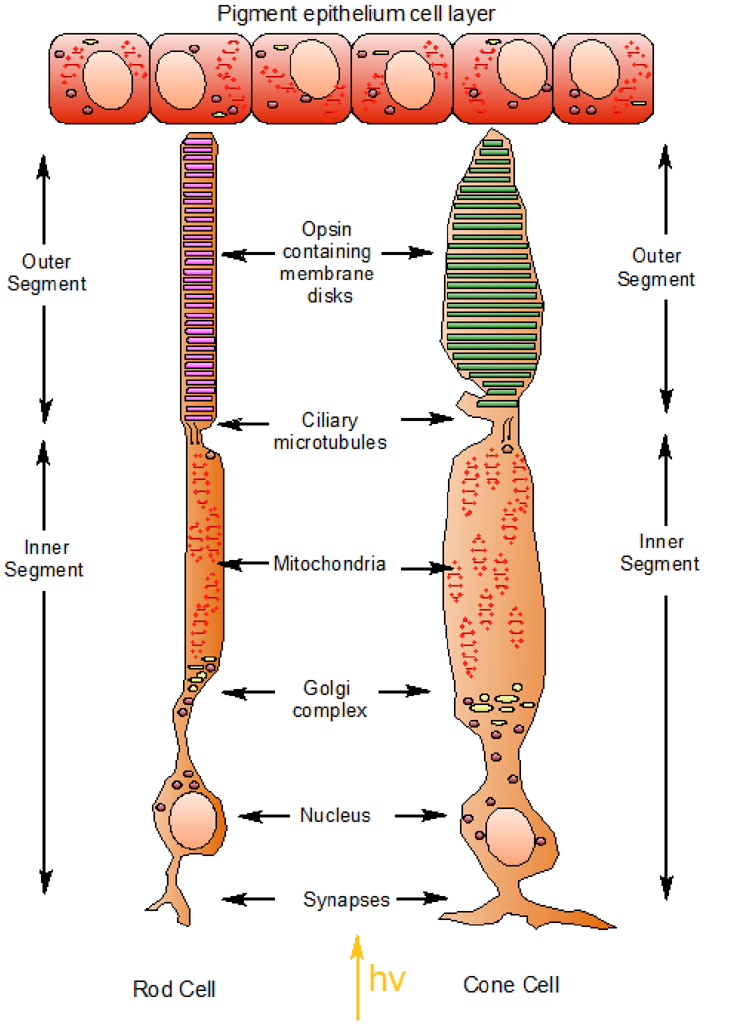

Figure 3. Photoreceptors of the retina are composed of rods and cones cells.

Because of the layout of the photoreceptors in the retina, light not only has to reach the retina but all the light rays have to converge on a focus point and create a retinal image on a specific area called the fovea.

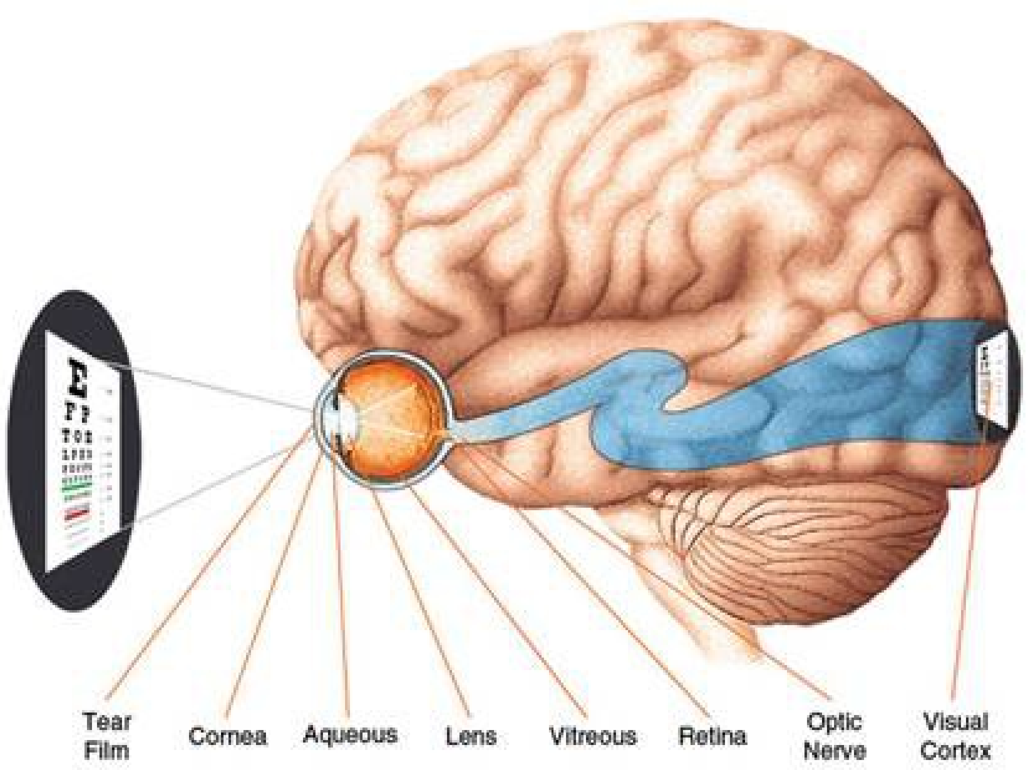

Figure 4. Visual system. Light enters the system through the cornea and is phototransducted into electrical impulses that are processed by the visual cortex in the occipital lobe.

Visual quality, thus, depends on the correct functioning of all the parts of the system in order for retinal image to be focused and the information can get to the brain.

VISUAL ACUITY

Visual acuity measurement has been the standard parameter when assessing a person's vision. It refers to the resolution capacity of the eye to discriminate fine details that corresponds to light deflections over the retina in small visual angles, typically in the order of 1 minute of arc (0.02º). In other words, it is the minimum distance needed between two objects so the eye can identify them as two different objects. This resolution is limited by the cones disposition over the fovea, as mentioned above. In order for two points to be resolved as separate objects, two cones have to be stimulated leaving an unstimulated one between them. Visual acuity can be affected specially by optical imperfections in that scale, that is, optical aberrations, of which defocus is usually the most important.

Reading charts are used to assess visual acuity. Von Jaeger designed the first of such charts that was printed in different languages. But it was until 1862 when Hermann Snellen published an acuity chart based on the disposition of the cones in the fovea. The letters from his charts, which he called optotypes, fit in a 5x5 grid, each grid subtending one minute of arc (figure 5).

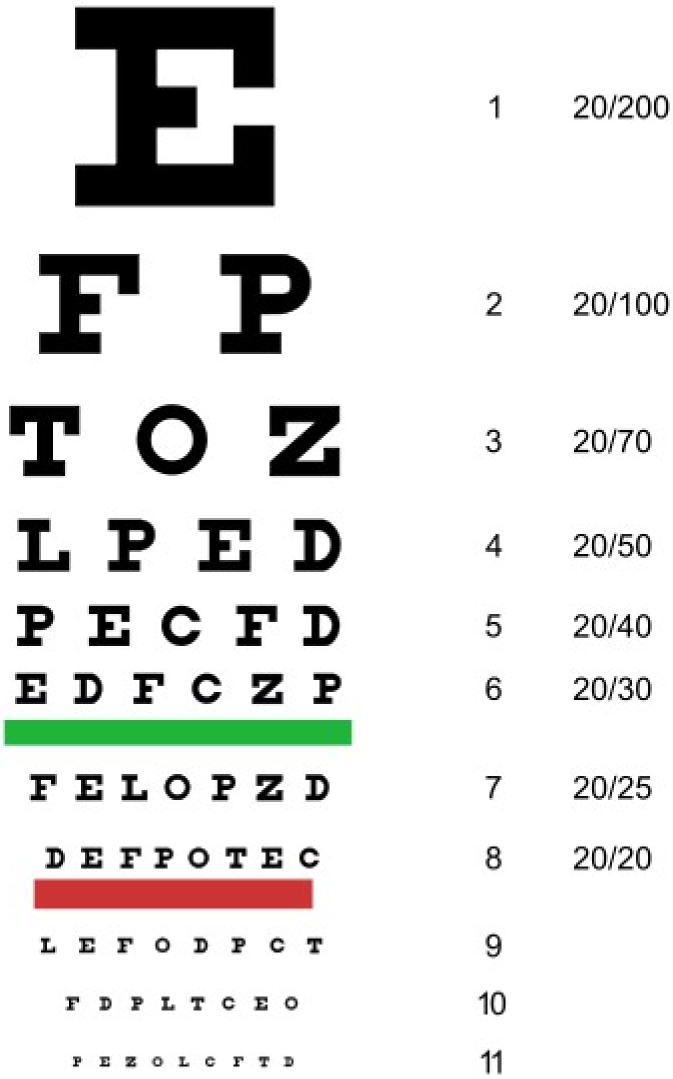

Figure 5. Snellen's visual acuity chart.

A few years later, John Green proposed a reading chart with geometric progression of the letter sizes and proportional spacing between them but it was not well received at that time.

In more recent years, the group of Early Treatment of Diabetic Retinopathy Study designed a reading chart that was used as the standard method for visual acuity testing. This chart have similar characteristics to the Jon Green’s chart (figure 6).

Figure 6. ETDRS visual acuity chart.

CONTRAST SENSITIVITY FUNCTION

Contrast is the difference in luminance of two different objects or within the same object. Unlike visual acuity testing, where the optotypes have a high contrast (black letters on a white background), visual task in the real world involve varying contrast.

Photoreceptors in the retina need a determined difference in luminance level to distinguish objects. The minimum difference in contrast needed is the sensitivity threshold. A common way to measure this threshold is by using sinusoidal grating patterns that can be adjusted to any size so they can also be used for assessing the resolution capacity of the eye. The size of the grating can be expressed in cycles per degree of visual angle, one cycle consisting of one dark line and one light line.

Contrast sensitivity charts consists of grating patterns with varying spatial resolution, or cycles per degree that progressively decrease contrast until a threshold is reached (figure 7). Contrast sensitivity is the reciprocal of the contrast threshold for a given spatial frequency.

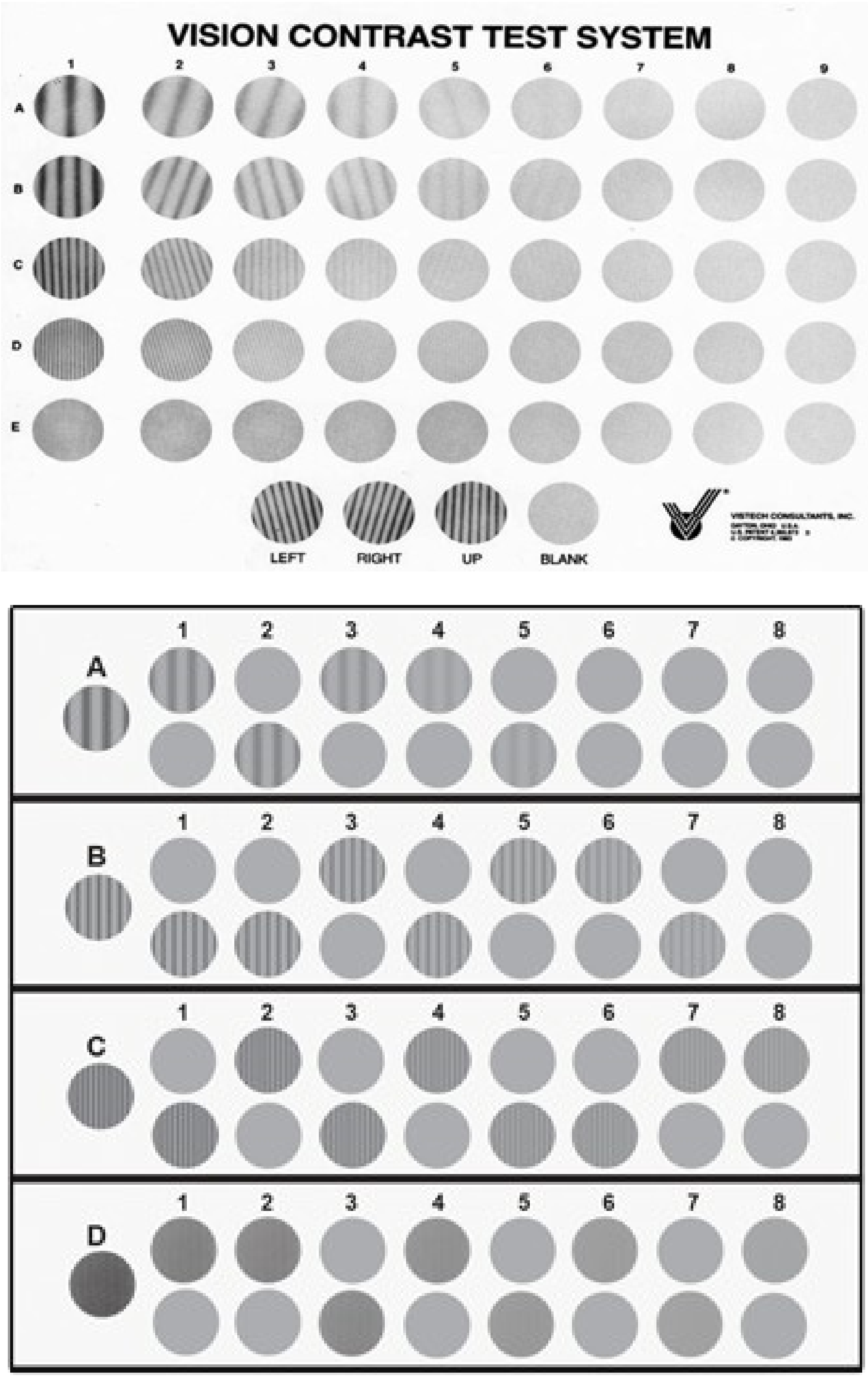

Figure 7. Two different contrast sensitivity charts.

STRAYLIGHT

It is well known that light coming from a glare source may produce discomfort or even impair vision. Glare phenomenon has been studied for many years, but it wasn't until the early 20th century when Cobb (Cobb, 1911) introduced the concept of equivalent veiling luminance, which was later on used by Holladay (Holladay, 1926) to propose his disability glare formula, explaining that light coming from a glare source produced a veil of light on the retinal image and postulated that this glare was due to the scatter of light in the eye media.

After all this investigation, the CIE came to define disability glare as straylight. Intraocular straylight is normally present in the human eye to certain extent (figure 8). If a disturbance sets in the optical media, the scatter of the light entering the eye increases and may produce not only discomfort but also deleterious effects on visual quality such as hazy vision, loss of contrast and color, or glare disability. (Franssen and Coppens, 2007)

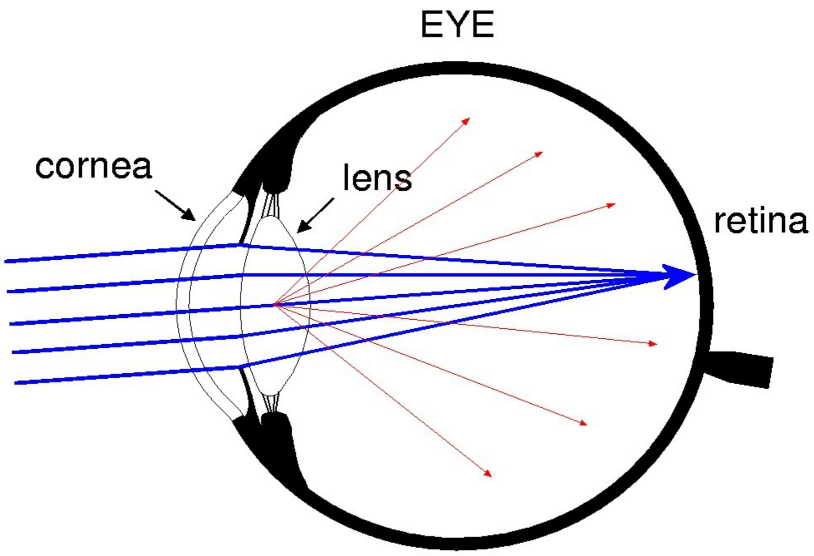

Figure 8. Intraocular light scattering producing a veil of light on the retinal image

Straylight measurement

Recently, Franssen et al. (Franssen, 2006) proposed the compensation-comparison method as a reliable and objective way to measure intraocular straylight, implemented on a portable device called the C-Quant (Oculus GmbH, Wetzlar, Germany). To measure the straylight, the eye fixates in the central dark circle of the test field, which is divided in two semicircles (left and right). A flickering glare source with a known luminance is then presented to the eye, coming from a ring shaped light in the periphery of the test field at an angular distance of 7º. Light emitted from the ring is scattered in the eye resulting in the perception that the central test field is flickering. A counter phase compensation light is then presented in one of the semicircles, reducing the flickering perception on that side. The patient is then asked to choose the side without the compensation light (i.e. the side that flickers more strongly). This process is repeated a set number of times with different levels of compensation light. The value obtained, is the logarithm of the straylight parameter (s). (figure 9)

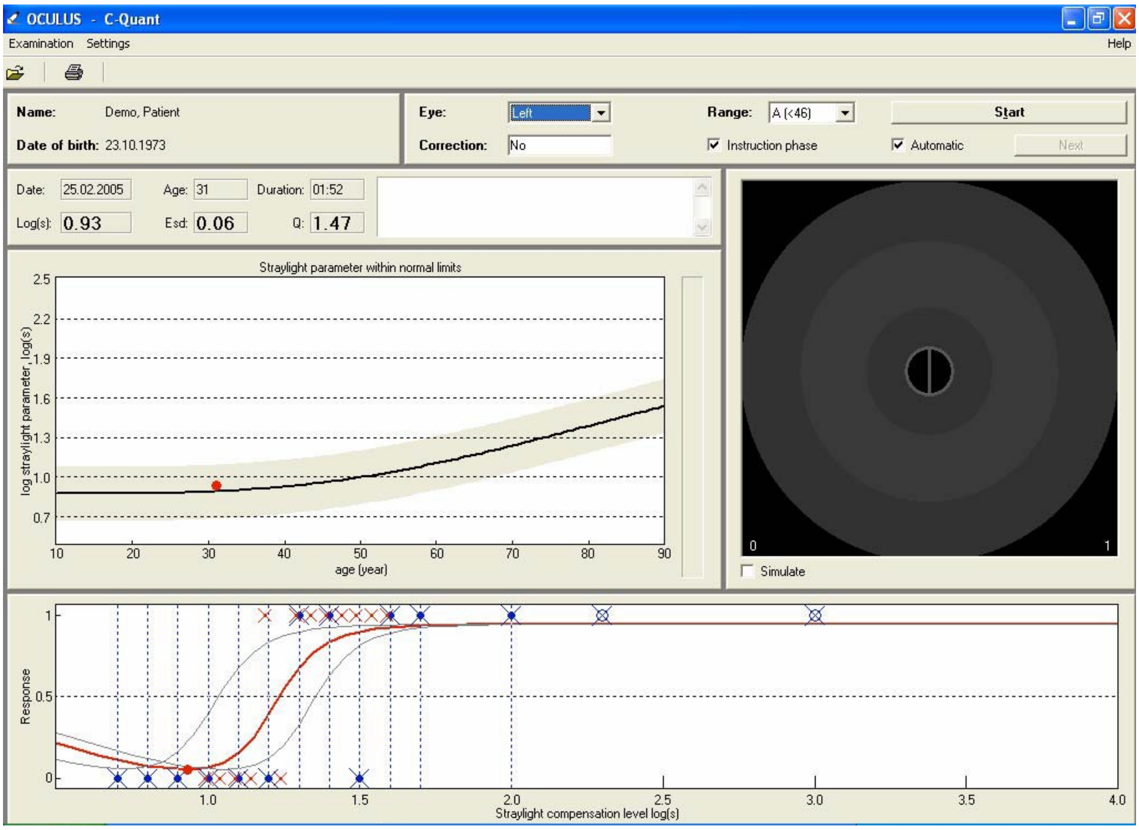

Figure 9. C-Quant operator screen after a measurement.

Large population studies using the compensation-comparison method to measure straylight have come to determine that young healthy eyes have a mean log[s] of around 0.87, remaining somewhat stable until the age of 40, when it starts to progressively increase. When straylight reaches a value of 1.47 log[s] it is considered to be highly impairing. (figure 10) (Van den Berg, 2007)

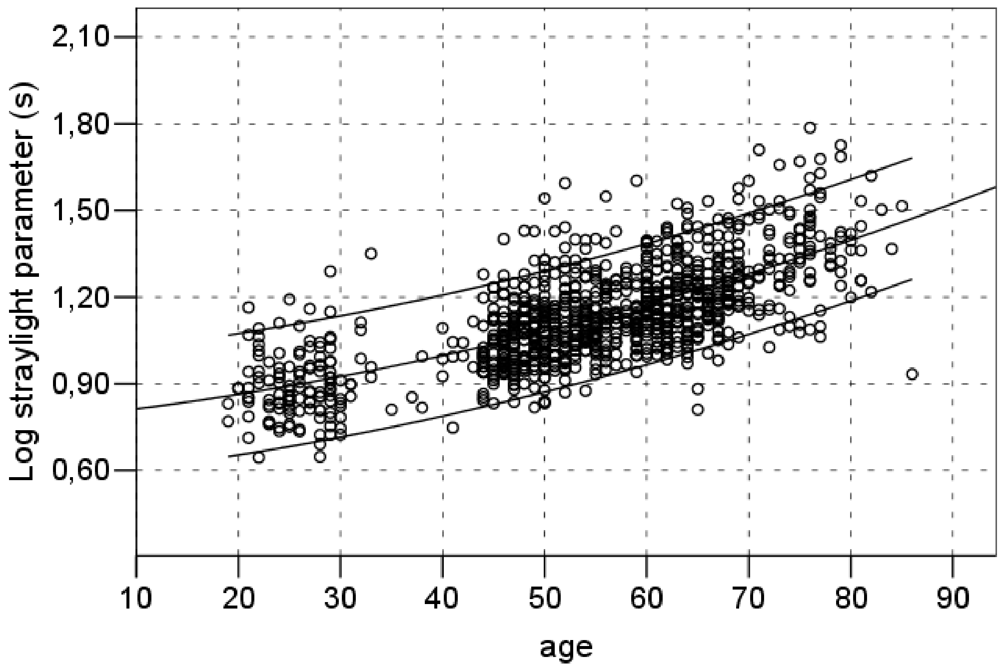

Figure 10. Log straylight parameter (s) in relation to age in the normal population.

The effect of increased intraocular straylight on vision is different from the effect of low visual acuity. These visual quality parameters are independently affected and they are not equally impairing. Visual acuity chart measure the eye capacity for resolution of small details, this is determined by light deflections over small visual angles on the retina, (1 minute of arc or 0.02º) commonly known as aberrations, whereas straylight measurement determines light scattering over larger angles (1 to 90 degrees). Moreover, the physical processes that cause these light deflections are different for the two angular domains. Thus, intraocular straylight and visual acuity have only a weak relation. (figure 11) (Franssen and Coppens, 2007)

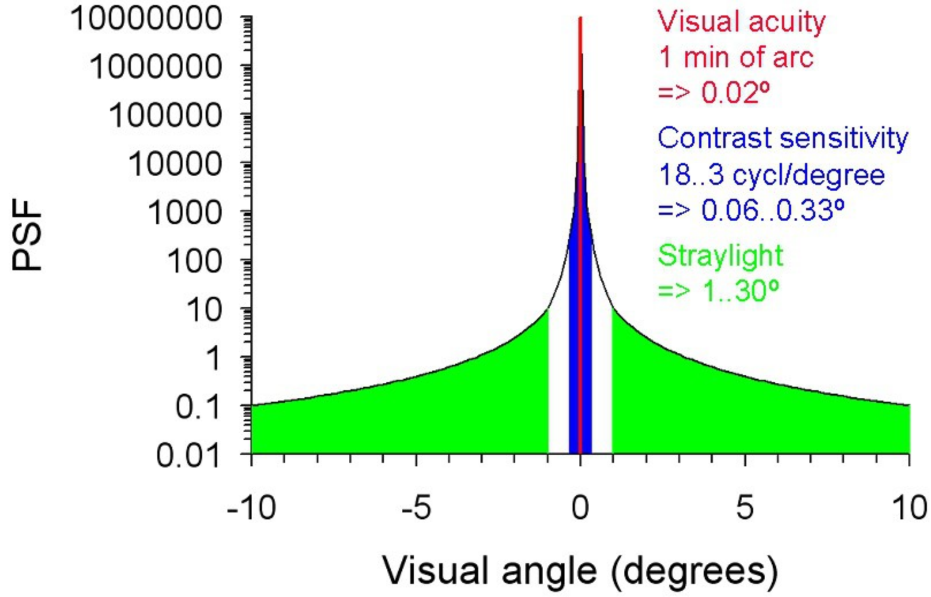

Figure 11. Relation of visual acuity, contrast sensitivity and straylight with the visual angle domain

Although intraocular straylight reduces contrast of the retinal image, the relation of straylight with contrast sensitivity function is also very weak. An increase of five times in straylight would only reduce the contrast sensitivity function by 20%. (Franssen and Coppens, 2007)

In the clinical setting, optical media disturbances or opacities are possible to assess with the use of a slitlamp. Nonetheless, that what is seen with the slitlamp is the light that reflects back from the opacities and therefore has a backward directed scattering. The C-Quant measures the light that is scatter in the forward direction, towards the retina. This scattering is the responsible for glare related symptoms in the eye. Thus, slitlamp derived visualization of media opacities cannot be used for the assessment of intraocular straylight, since there is not a direct relation between forward and backward light scattering.

Sources of straylight in the eye

Every component of the optical media, even in a normal eye without media disturbance, can cause a scatter of the light going to the retina. Main sources of straylight within the eye are: cornea, iris, sclera, crystalline lens and fundus. Each of these elements contributes a different percentage of the total straylight and may vary with age, pigmentation, associated ocular pathologies, or even as a side effect of ocular surgery. (Franssen and Coppens, 2007)

Cornea

In a normal healthy eye the cornea accounts for about one third of total intraocular straylight. This proportion remains rather constant with age, although certain corneal pathologies such as the presence of corneal opacities or corneal oedema (figure 12) may increase straylight in a greater proportion as compare to the effect on visual acuity, especially in some corneal dystrophies.

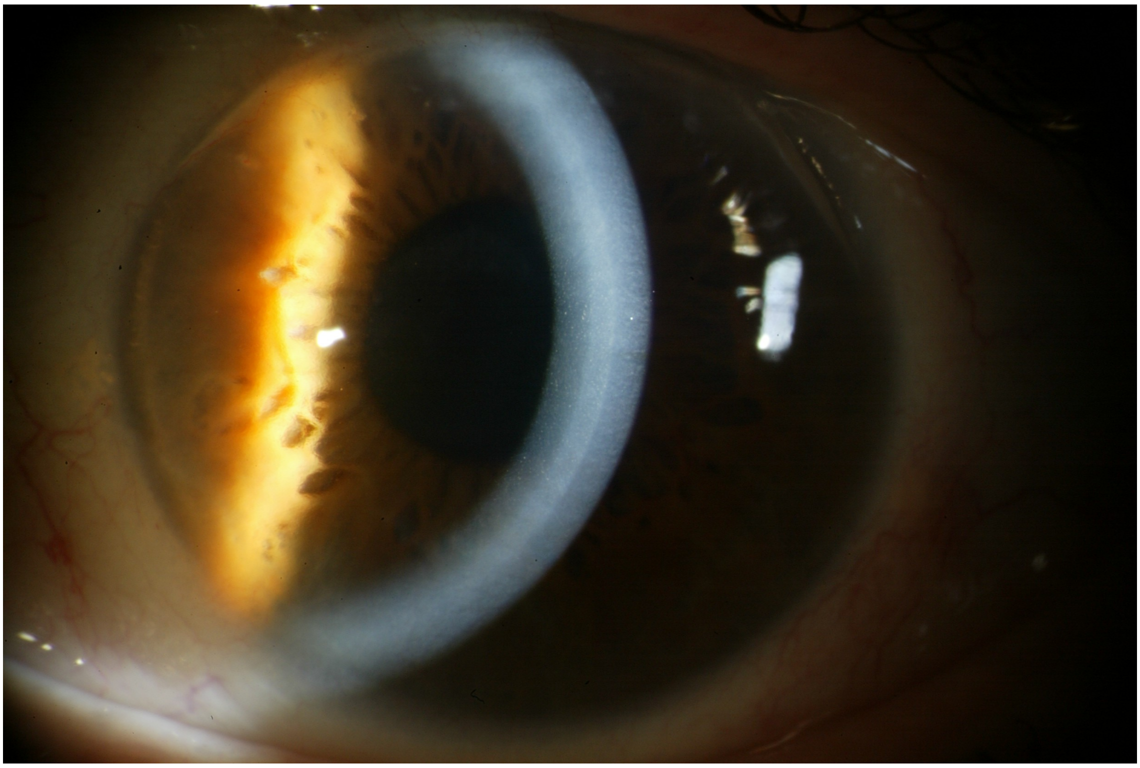

Figure 12. Corneal oedema in Fuchs' corneal dystrophy.

Even the wear of contact lenses can also have a negative impact on straylight, especially if they are dirty, scratched or have deposits on its surface. In the case of rigid contact lenses, increased straylight may persist even after wearing the lenses (van der Meulen, 2010).

It has been reported that intraocular straylight may temporarily increase after uneventful refractive surgery such as PRK (Veraart, 1995) and LASIK (Michael 2010). Although straylight returns to normal levels in most of the cases, some studies show that straylight remains elevated in approximately 5% to 20% of the cases, even in the absence of clinical findings (van den Berg, 2010). Moreovoer, common complications after these procedures, such as a diffuse lamellar keratitis (figure 13) may produce a further elevation of the straylight value.

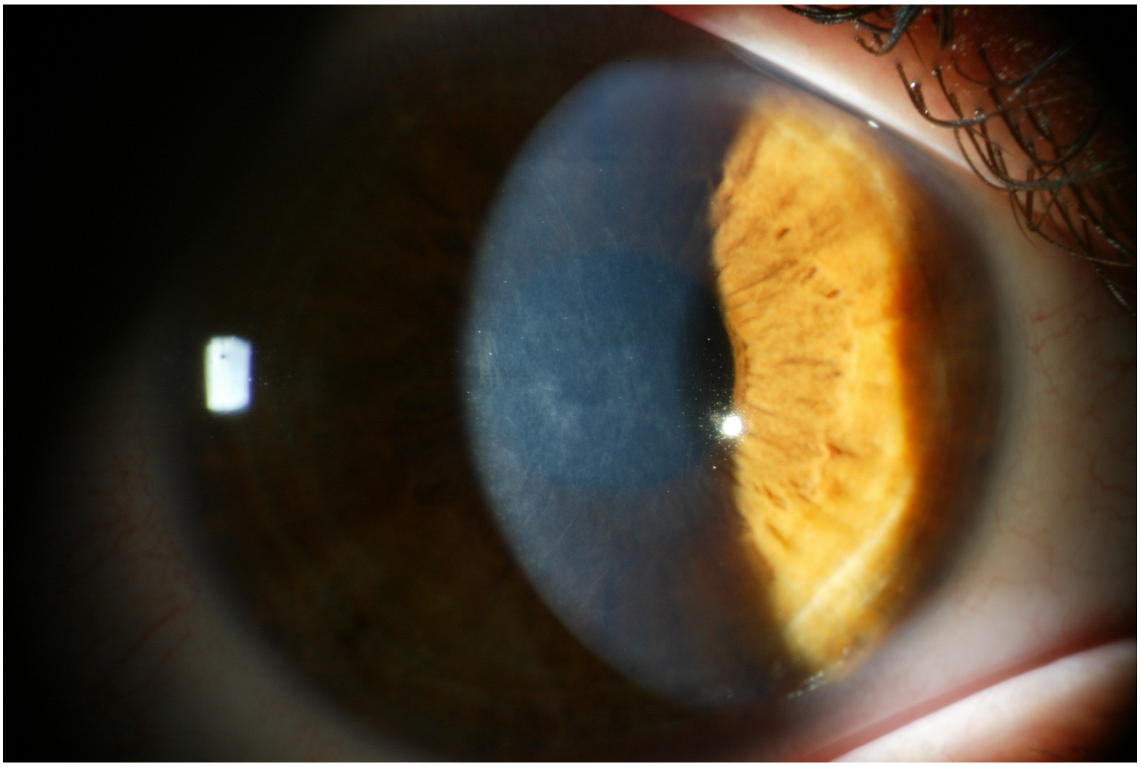

Figure 13. Diffuse lamellar keratitis after LASIK treatment.

Crystalline lens

Another one third of the total straylight in a normal eye is due to the crystalline lens (Franssen and Coppens, 2007), which on the other hand, does increase with age due to cataract formation. Measured intraocular straylight increases continuously with cataract severity as estimated by the mean lens opacity clasification system (LOCS) score (Michael, 2009). (figure 14) Mean intraocular straylight for the lowest LOCS score (0.1) is about 1.0 log[s] and with a LOCS score for mild cataract (> 0.75) about 1.4 log[s]. This corresponds to a more than threefold increase of straylight. Intraocular straylight is much better correlated to cataract severity than both visual acuity and contrast sensitivity (Michael, 2009). A low correlation has been found between individual LOCS scores and the Visual Functioning Questionnaire VF-14. Only the LOCS score on posterior subcapsular opacity gave a high correlation (Heys, 2008).

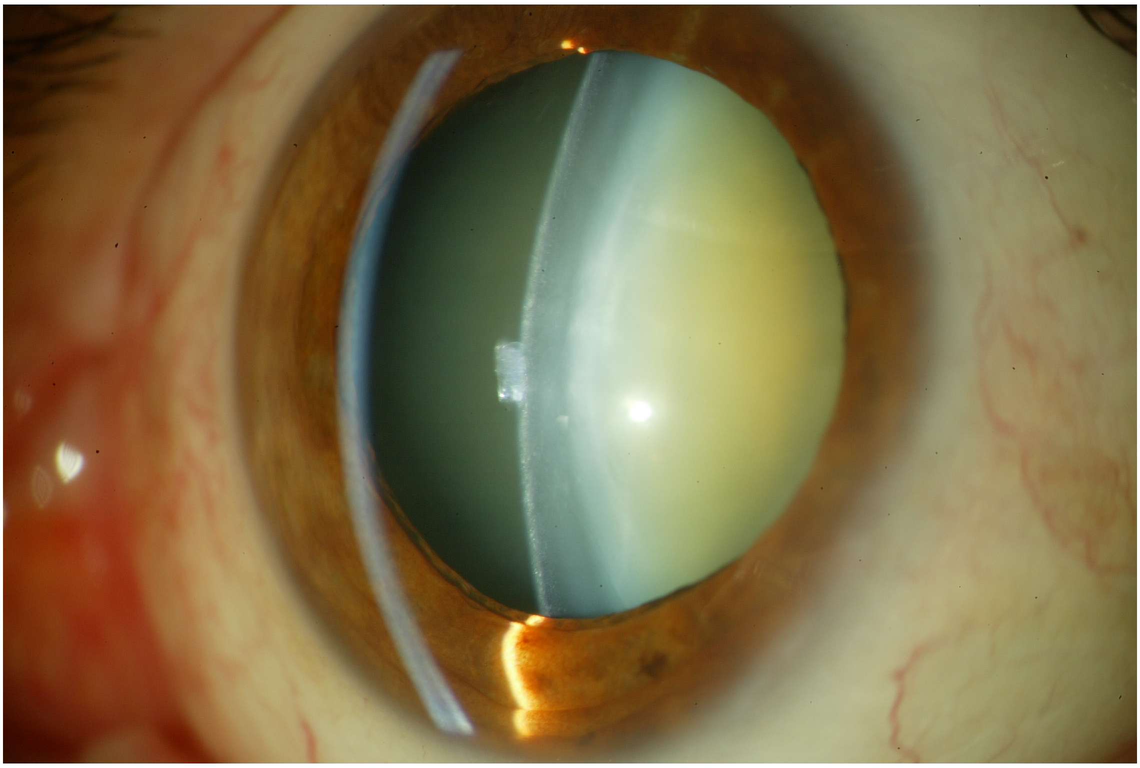

Figure 14. A dense cataract greatly increases intraocular straylight.

Lowest values of intraocular straylight are found in nuclear cataracts (1.19 log[s]), followed by cortical (1.20 log[s]) and posterior subcapsular cataract (1.23 log[s]). Mixed nuclear and cortical cataracts have a mean of 1.30 log[s] and mixed nuclear, cortical and posterior subcapsular cataract a mean of 1.35 log[s]. Nuclear cataracts have a significant better visual acuity and straylight values than mixed cataracts.

Even though increased straylight due to cataract formation can be reduced after cataract extraction surgery, other issues may present that elevate intraocular light scattering once again. Opacities in the intraocular lens (IOL) or even lens material may influence the amount of light that is scattered. (figure 15) It has been reported that Hydrophobic acrylic IOLs induce more straylight than hydrophilic acrylic ones (Montenegro, 2010). Hydrophobic acrylic IOLs have largely been studied for their high incidence of glistenings. IOL glistenings could cause increased straylight, but there is no published information confirming this.

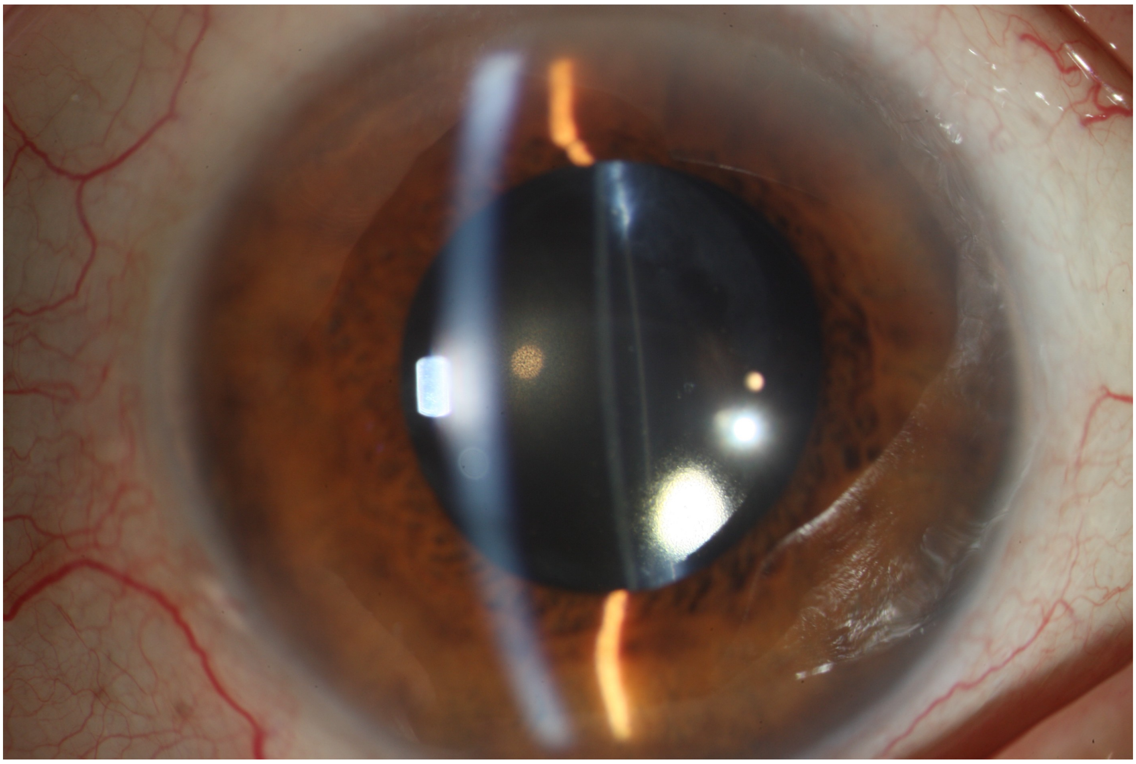

Figure 15. IOL opacification

Opacification of the posterior capsule is the most common complication after cataract extraction surgery. This opacification can significantly increase intraocular straylight (figure 16). Studies have shown that small capsulotomies with large capsule remnants inside the pupilary area are the cause of maintained or even increased intraocular straylight after posterior capsulotomy (Montenegro, 2010).

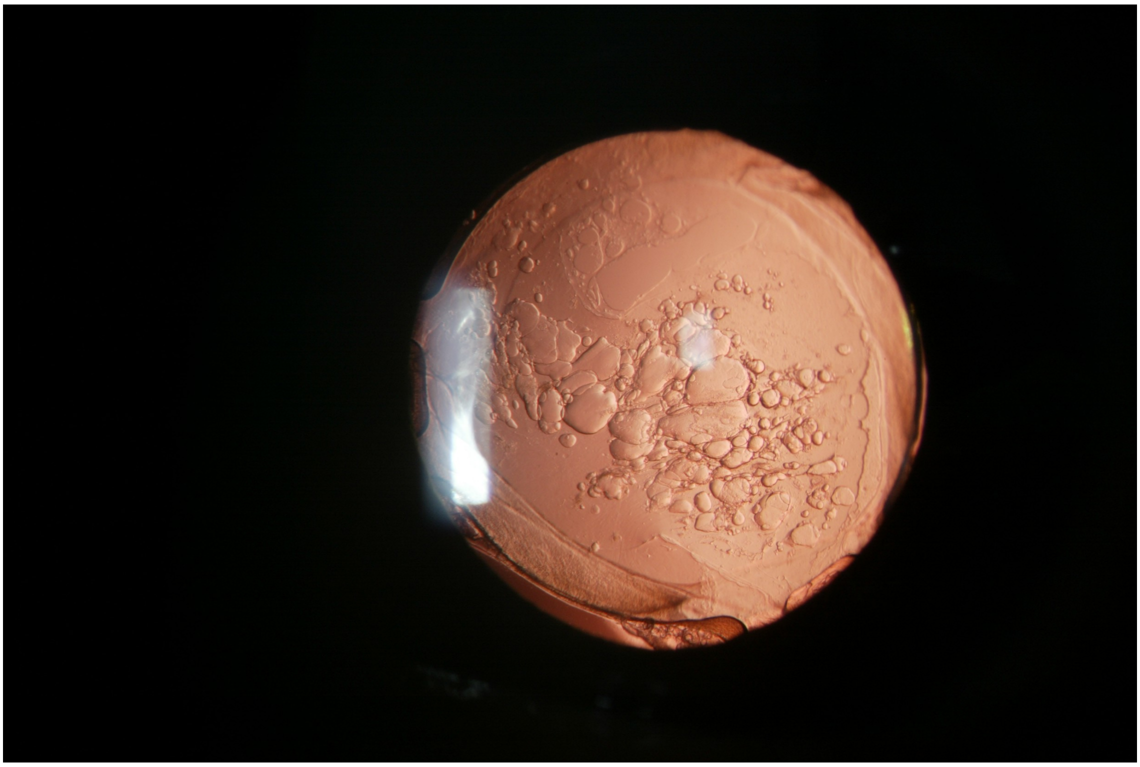

Figure 16. Posterior capsule opacification increases straylight.

Iris, sclera and fundus

The iris, sclera and fundus contribute to the remaining one third of the intraocular straylight and are dependent on pigmentation. Light that reaches the iris and sclera can be transmitted to the retina in an eye with low pigmentation. As in the iris and sclera, light that falls on the fundus is not totally absorbed and can be scattered back to other parts of the retina (Franssen and Coppens, 2007).

Aqueous humour and vitreous gel

Normally, aqueous humour does not contribute to intraocular straylight but can increase its levels in the presence of turbidity (Tyndall). As aqueous humour, vitreous gel does not normally increase straylight, but some alterations such as floating bodies, or vitreous opacities such as asteroid hyalosis can greatly increase straylight, often without affecting visual acuity (figure 17).

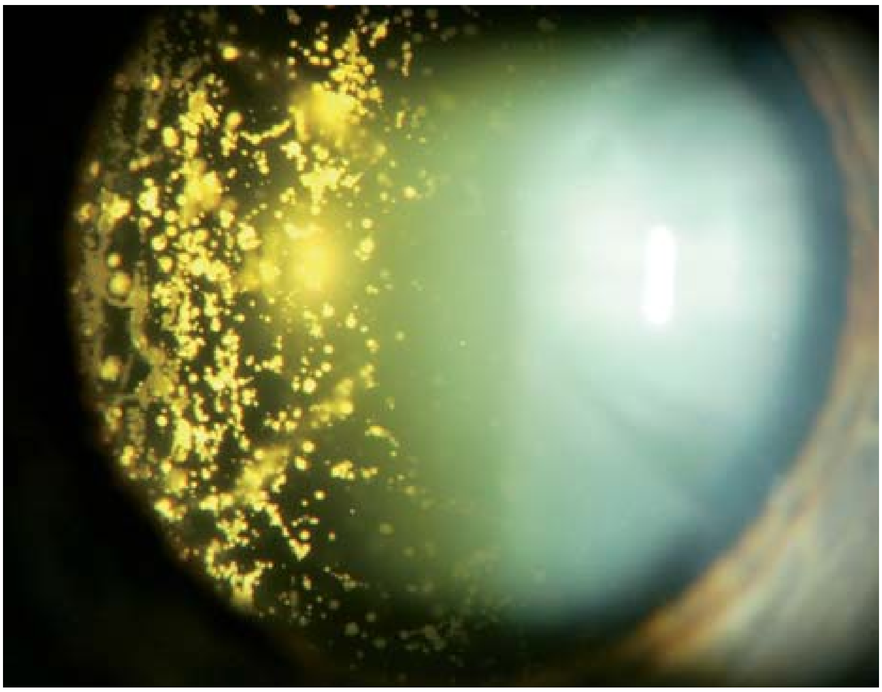

Figure 17. Vitreous condensations can increase intraocular straylight, as in this case of asteroid hyalosis.

LITERATURE REVIEW

REFRACTIVE SURGERY

Over history, many different approaches have been performed to try correcting refractive errors of the eye. Some of the techniques employed included resection of sclera for myopia correction. Nevertheless, most of the procedures have focused on the cornea.

It could be said that refractive surgery was born when correction of corneal astigmatism was first attempted. After cataract surgery was popularized by von Graefe, it was noted that astigmatism was influenced by corneal shape. Thereafter, multiple attempts to surgically correct astigmatism were performed. In 1885, Schiotz reduced post-cataract astigmatism by performing internal keratotomy incisions, and in 1895 Farber tried to reduce naturally occurring astigmatism.

More recently, in 1949 Barraquer was the first to describe the principles of lamellar surgery. He removed a disc of the anterior portion of the cornea (the equivalent of today's corneal flap) with an instrument called a microkeratome, and then he froze the disc, and ground it into a new shape with a mechanical lathe called the cryolathe, changing the cornea's curvature.

Laser in-Situ Keratomileusis (LASIK) is currently one of the most widely used laser refractive surgeries. Over the years it has been continuously improving thanks to the fast advancing laser technology and the consequently more refined techniques, providing a better correction of refractive errors and high order aberrations. As a result, these procedures give very predictable and outstanding outcomes, in terms of visual acuity. However, it has been noted that even patients with an excellent visual acuity may sometimes complain of bad vision. Contrast sensitivity and intraocular straylight are known to have an impact on visual performance (Michael, 2008; Van den Berg, 2007) and could explain some of the patients' complaints.

Therefore the purpose of this study is to quantify the variation, if any, in the level of intraocular straylight and contrast sensitivity in patients who underwent LASIK surgery.

There is no agreement on the effects of LASIK on contrast sensitivity. Some authors suggest that there is a decrease in contrast sensitivity after LASIK (Marcos, 2001; Yamane, 2004), whereas others believe there is no change or even an improvement, depending on the technique (Lee, 2006; Kim, 2007).

Considering straylight, there are only a few studies. Lee et al. (2006) found a post-op increase of straylight in LASIK patients and Kim et al. (2007) reported no change post-op. Both used the subjective ALC Glare test where the patient looked at the white spot (316 pixels) displayed on a 17-inch TFT LCD monitor (1024x768 resolution) positioned 50 cm from the patient. The patient had to draw the boundary of the halo they saw on a graphics tablet. The area of the halo was then automatically calculated in pixels or square millimetres. Beerthuizen et al. (2007), using the C-Quant, found no variation in intraocular straylight one month after LASIK.

We measured contrast sensitivity at four different spatial frequencies using the CSV-1000 (Vector Vision; Haag Streit, Harlow, UK). The C-Quant straylight meter (Van den Berg, 2007) was employed to measure intraocular straylight.

HYPOTHESIS

Intraocular straylight increases after Laser in-Situ Keratomileusis.

OBJECTIVES

To compare the levels of intraocular straylight before and after LASIK treatment.

To compare the contrast sensitivity function before and after LASIK treatment.

To compare visual acuity measurements before and after LASIK treatment.

To assess the effects of LASIK on visual quality by the use of three different visual function tests.

METHODS

Study Population

This prospective study includes 46 eyes of 28 patients from the *Centro de Oftalmología Barraquer,* Barcelona, who were eligible for LASIK surgery, after excluding lens opacities, macular lesions, or any other anatomic anomaly of the eye globe. All the subjects in the study were treated for LASIK with Bausch & Lomb Technolas Z100. We included conventional ablation profiles (Planoscan and Cross Cylinder, n = 23) and wavefront-guided ablation profiles (Zyoptx, n = 23). One day prior surgery patients went through a full ophthalmologic examination with registration of uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), contrast sensitivity and straylight measurements. Preoperative spherical error ranged from -8.0 to +3.5 dioptres, with 39 myopes (mean -4.0 dioptres) and 7 hyperopes (mean 2.1 dioptres). The age of the patients ranged from 22 to 50 years, with an average of 30 years. Two months after surgery a full evaluation was performed again.

Straylight Measurements

Values for intraocular straylight were obtained using the C-Quant (Oculus GmbH, Wetzlar, Germany). This is a commercial version of the third generation straylight meter, implemented on a personal computer. The C-Quant measures intraocular straylight based on the Direct Compensation method (Franssen, 2006). The test field is divided in two half circles that flicker at 8 Hz. One side has the counter-phase compensation light. The patient must choose the side that seems to flicker more strongly. To assure the quality of the measurements, the test was repeated up to three times in case the computer software indicated low reliability. If the result was still unreliable, the subject was excluded from the study. Values were expressed as log[straylight parameter] (log[s]) (Van den Berg, 2004). Higher straylight values indicate a higher sensitivity to glare and thus a more compromised visual function.

Contrast Sensitivity Measurements

Contrast sensitivity was measured using the CSV-1000 (Vector Vision; Haag Streit, Harlow, UK) at 3, 6, 12 and 18 cycles/degree. The CSV-1000 consists of a back lighted chart that presents sine wave gratings with four different special frequencies. Each frequency is presented on a separate row on the chart. There are 17 patches for each row. The first patch has a high contrast grating and identifies the spatial frequency for that row. The remaining 16 are paired in eight columns across the row. For each pair, one patch presents the grating, whereas the other is blank but of the same luminance. The patches decrease 40% in contrast across the row from left to right. The patient must choose which patch has the grating for that column. The contrast threshold is measured from the last correct response. The contrast sensitivity levels in each row range from 0.7 to 2.08; 0.91 to 2.29; 0.61 to 1.99; and 0.17 to 1.55 log units for 3, 6, 12, and 18 cycles/degree respectively (User manual CSV-1000).

Statistical Analysis

Mean and 95% confidence interval is given and the Students t-test was used to compare straylight and contrast sensitivity values; $p < 0.05$ was considered significant. The computer based statistical software SPSS 13.0 for Windows (SPSS, Chicago, Ill.) was used for the analysis of the data.

RESULTS

Pre-operative best spectacle-corrected visual acuity (BSCVA) was 0.029 ± 0.011 logMAR (mean ± confidence interval (CI)), which corresponds to a mean of 0.93 on a decimal scale. Post-operative (2 month) BSCVA was 0.041 ± 0.014 logMAR (0.91 decimal). There was no significant change in the mean of the individual post minus pre operative differences, considering the BSCVA (0.01 ± 0.01; p = 0.09). One eye (2 %) lost 2 lines of BSCVA. Post-operative UCVA was 0.091 ± 0.041 logMAR (0.81 decimal). The mean safety index (BSCVA post / BSCVA pre) was 0.98 and the mean efficacy index (UCVA post / BSCVA pre) was 0.90. Except for two eyes (4%), there were no clinically significant complications post-operatively. One case showed a diffuse lamellar keratitis (DLK) and an increased optical density within the flap-cornea interface and the other a light paracentral superficial punctuate keratitis (SPK). The DLK patient was 50 years old, was corrected for +1 diopter and had a pre-op decimal BSCVA of 0.90 and post-op of 0.75. The SPK patient was 29 years old, was corrected for -5.25 dioptres and had a pre-op decimal BSCVA of 0.95 and post-op of 0.85. Figures 18 and 19 show the clinical appearance of both cases.

Table 1: Mean individual differences (2 months post minus pre LASIK) of best spectacle corrected visual acuity (BSCVA), straylight and contrast sensitivity (CS); considering all eyes together, a group of cases without 10 eyes that presented variations of two or more positions in CS and for the 10 excluded eyes alone. A negative BSCVA difference, a negative straylight difference or a positive CS difference reveals a post operative improvement

	All eyes (n = 46)		Without extreme CS cases (n = 36)		Extreme CS cases (n = 10)	
Difference (post - pre)	**Mean ± CI**	**p**	**Mean ± CI**	**p**	**Mean ± CI**	**p**
BSCVA (logMAR)	0.01±0.01	0.09	0.01±0.01	0.06	0.00±0.04	0.84
Straylight (log [s])	-0.02±0.05	0.43	-0.05±0.06	0.07	0.09±0.09	0.05
CS at 3 cyc/deg (log [c])	0.01±0.03	0.44	0.03±0.04	0.08	-0.06±0.08	0.10
CS at 6 cyc/deg (log [c])	-0.01±0.06	0.69	0.05±0.05	0.03	-0.25±0.18	0.01
CS at 12 cyc/deg (log [c])	-0.05±0.09	0.26	0.05±0.05	0.03	-0.43±0.03	0.01
CS at 18 cyc/deg (log [c])	-0.05±0.10	0.30	0.07±0.05	0.01	-0.49±0.31	0.01

CI = confidence interval; p = significance coefficient obtained using the paired Students *t* test.

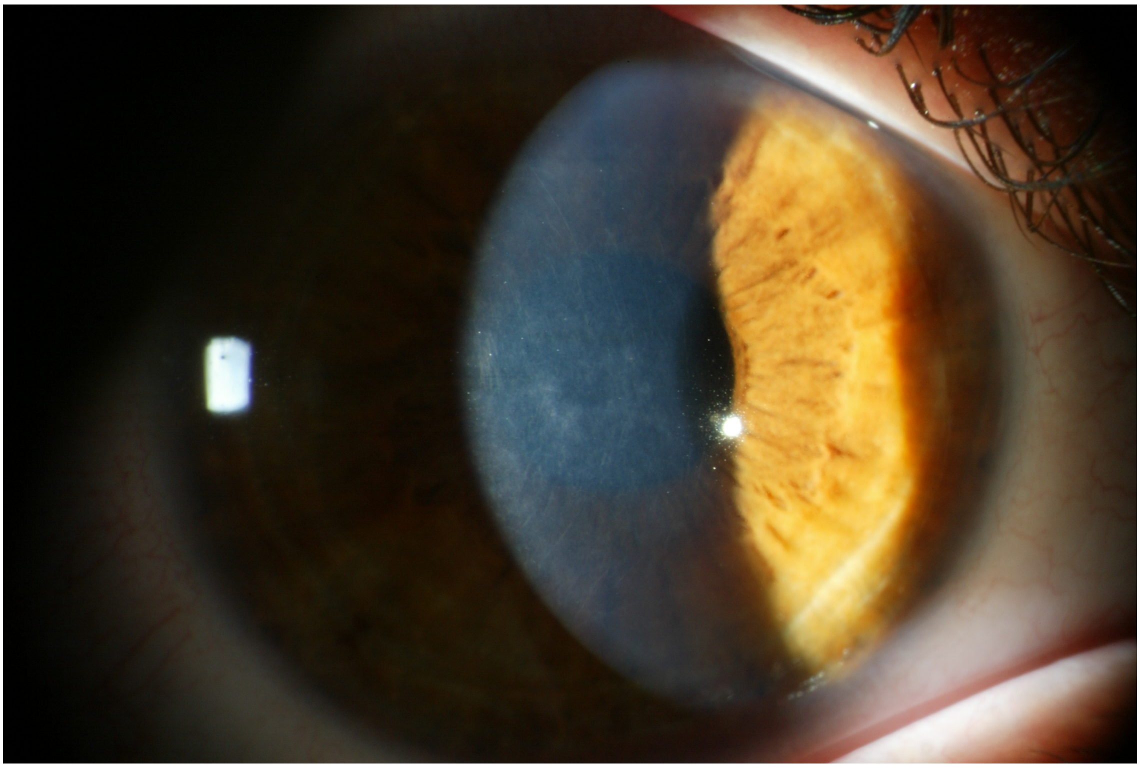

Figure 18. Slit lamp view of the eye with diffuse lamellar keratitis and an increased optical density within the flap-cornea interface.

Figure 19. Slit lamp view of the eye with light paracentral superficial punctate keratitis.

We found a straylight value of 0.98 ± 0.04 log(s) (mean ± CI) pre operatively and 0.96 ± 0.05 log(s) post operatively. There was no statistically significant variation in post-operative straylight values compared to those pre operatively (-0.02 ± 0.0,5; p = 0.43). Only one eye had an increase of more than 0.25 log units in straylight post operatively (Fig. 20). This was the patient with diffuse lamellar keratitis. Straylight increased from 1.03 to 1.46 log(s). The patient with superficial punctuate keratitis did not have a significant change in his straylight values (pre-op 1.07 and post-op 1.02 log(s).

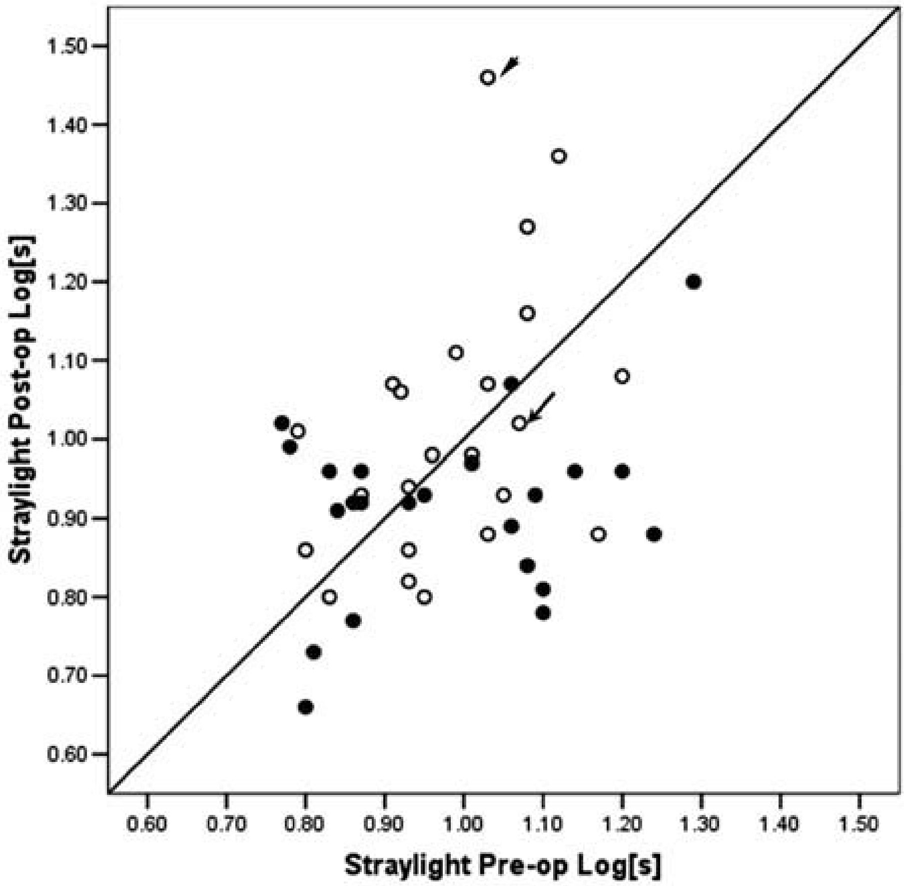

Figure 20. Straylight values before and 2 months after LASIK measured with the C-Quant. Data points below the solid line reveal improved straylight values post operatively. Full circles denote conventional ablation profiles and open circles wavefront-guided ablation. The small arrow indicates a patient with light superficial punctuate keratitis and the arrow head a patient with diffuse lamellar keratitis post operatively.

A few eyes had already pre operative contrast sensitivity values below the normal range for their age (as defined by the CSV-1000 manual); 4 eyes at 18 cyc/deg and 1 eye at 12 cyc/deg. They remained there stable post operatively (Fig. 21).

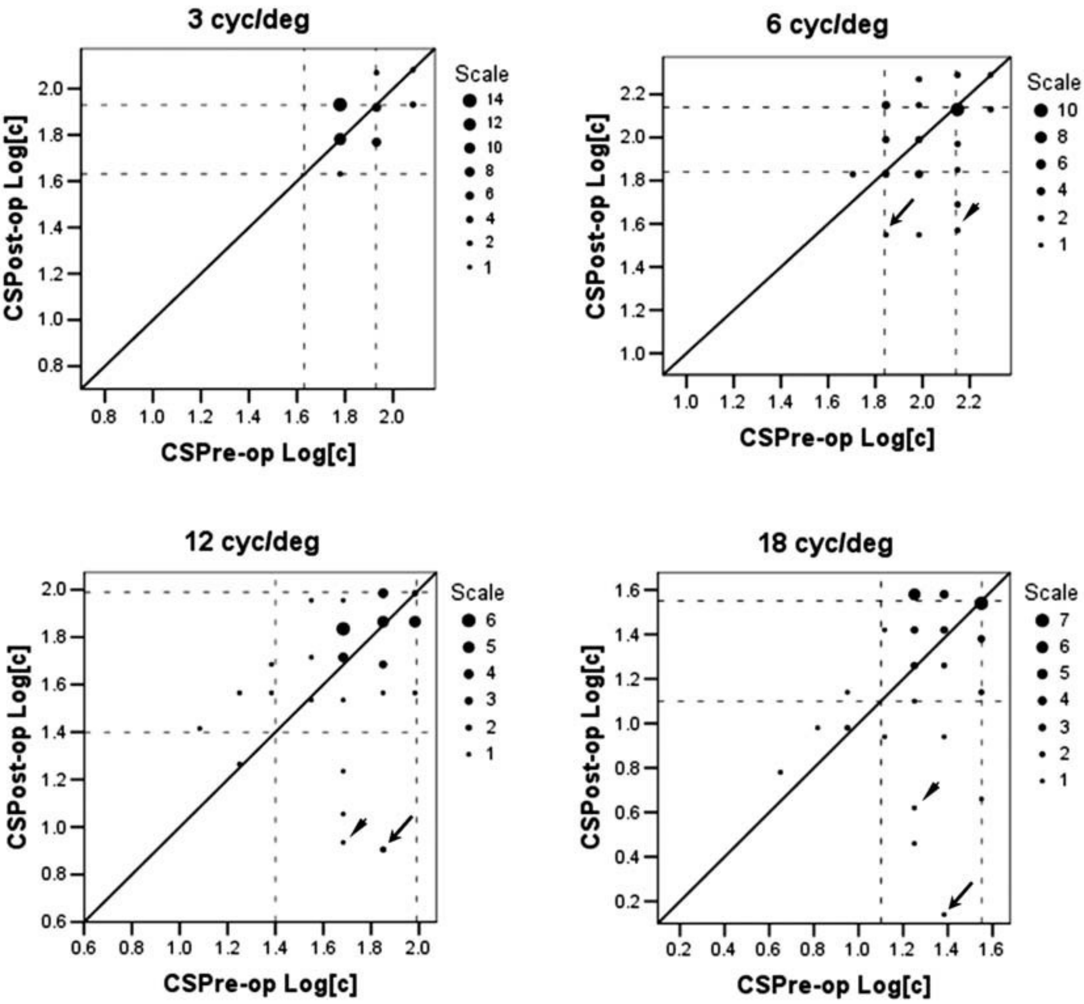

Figure 21**.** Contrast sensitivity logarithmic values before and 2 months after LASIK for each spatial frequency measured with the CSV-1000. Data points above the solid line reveal improved contrast sensitivity post operatively. For each spatial frequency, the dashed lines indicate the normal range from the CSV-1000 for ages 20 to 59 years. The small arrow indicates a patient with light superficial punctuate keratitis and the arrow head a patient with diffuse lamellar keratitis post operatively.

Contrast sensitivity values did not change significantly. However, important individual variations were observed in 10 eyes. Nine eyes (20%) presented a decline of two or more positions in the CSV-1000 log scale at one or more spatial frequencies and one eye an increase of three lines. Only two of those eyes had a clinical explanation for the decrease, one presented the light paracentral superficial punctuate keratitis and the other case was the patient with the diffuse lamellar keratitis (Fig. 21). Of the cases that presented an unexplained postoperative decrease in the contrast sensitivity values, only some fell below the normal range for their age; 2 eyes at 6 cyc/deg, 3 eyes at 12 cyc/deg and 4 eyes at 18 cyc/deg (Fig. 21).

The wavefront-guided group regained their pre-op BSCVA whereas the conventional group had a minor decrease. The ablation technique had no significant influence on post-pre operative straylight or contrast sensitivity changes.

DISCUSSION

The study population consisted of normal subjects with a good BSCVA and without lenticular or retinal lesions who were eligible for LASIK surgery. Post-operative results for UCVA and BSCVA were normal as well. We had two cases (4%) with clinically significant complications; one patient with diffuse lamellar keratitis (DLK) and another one with light paracentral superficial punctuate keratitis (SPK).

DLK is an inflammatory response to multiple stimuli, but it is mostly associated to sterilizers with reservoirs, and it can occur in 0.4 % of the LASIK patients (Stulting, 2004; Villarrubia, 2007). A meta-analysis for worst case economic impact showed an incidence of 6.5 % of inflammatory complications after LASIK, where DLK was included (Lamparter, 2007) SPK is a corneal defect that presents usually as central doted ulcerations of the epithelium and may course with a slight decrease of visual acuity. It is associated with a variety of conditions such as dry eye, immune reactions, denervation and abrasions, among others. The DLK explains the important increase in straylight and the decrease in contrast sensitivity for this patient. The SPK case was described as light and paracentral inferior by the physician and showed only a decrease in contrast sensitivity, but not an increase in straylight.

On average, there was no significant change in straylight at 2 month after LASIK. This is in accordance with an earlier study by Beerthuizen et al. (2007) He observed no significant increase in straylight one month after LASIK, but three cases with an increase of more than 0.2 log(s). Clinically, 2 eyes had microstriae in the flap and 1 eye had a significant amount of debris under the flap. Two other studies by Lee et al. (2006) and Kim et al. (2007) applied the subjective ALC Glare test (described in the introduction). Lee found some increase in glare sensitivity at 6 months post LASIK under photopic and a more pronounced increase under mesopic conditions. Kim did not find a significant variation in glare sensitivity at 2 and 6 months post LASIK.

Our present study showed, on average, no statistically significant change in contrast sensitivity 2 months after LASIK surgery. However, 9% of the cases had a slight decrease in contrast sensitivity (but remained in the normal range of the CSV-1000) and 11% presented contrast sensitivity values below the normal range post-operatively. In the literature, there is no general consensus of the effect of LASIK on contrast sensitivity. Studies from 2001 and 2003 revealed a decrease in contrast sensitivity at 1, 2 or 6 months post operatively (Marcos, 2001; Yamane, 2004; Donate, 2005). More recent studies suggest that contrast sensitivity can return to baseline values or even improve depending on the surgical technique (Lee, 2006; Kim, 2007) Lee found a decrease in contrast sensitivity at 1, 3 and 6 months post-op conventional LASIK and no change at 6 months after wavefront-guided LASIK. One year later, Kim found no change after 2 and 6 month post conventional LASIK and an improvement after wavefront-guided LASIK. We found no significant change of contrast sensitivity post minus pre operative differences between the wavefront-guided and the conventional ablation group. The wavefront-guided group regained their pre-op BSCVA whereas there was a minor decrease in the conventional group.

CONCLUSIONS

In summary, LASIK patients seem to fall in three groups; one group, the vast majority (in our study 80%) has no complications and maintains their visual quality as judged by visual acuity, contrast sensitivity and intraocular straylight. A few patients (in our study 16%) have no clinically significant complications but a slightly decreased visual quality. Very few (in our study 4%) have clinical complications with decreased visual quality.

Since the introduction of the compensation comparison method, as implemented in the C-Quant straylight meter, a large amount of studies have shown the independence of straylight and visual acuity. For this reason the straylight value can be used as an additional descriptor of visual quality.

Recently a large European multicenter study group investigated about different tests for visual function and their impact on driving. The study emphasized on the impairment on vision caused by high levels of straylight. A log (s) of 1.4 was suggested as the cut-off value for save driving, in this way, straylight could be included as a criterion for driving legality (Michael, 2009; van den Berg, 2007 & 2009; van Rijn, 2009). A most recent study is in accordance with straylight consideration in driving legality and also as a complementary test when considering cataract surgery (Bal, 2011)

Another study proposes straylight measurement as a screening method for ocular fitness in demanding professions, such as military or pilots, particularly in subjects who underwent laser refractive surgery, who seem to have higher straylight values (van Bree, 2011).

In the clinical setting, straylight measurement can be used in addition to VA tests to assess visual quality after surgical procedures such as cataract surgery, refractive surgery, and lamellar keratoplasty; where excellent visual outcomes are expected by both the patient and the surgeon.

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