Ocular straylight in the normal pseudophakic eye

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ABSTRACT

Purpose

To assess normal values for straylight in the pseudophakic eye as a function of age and to develop a model to predict the improvement in straylight after lens extraction based on preoperative straylight levels.

Methods

A literature review was performed to identify relevant papers on straylight and pseudophakia with no patient comorbidities. Sixteen papers met the eligibility criteria and were included in the analysis. The postoperative results were used to define the norm for straylight in pseudophakia. Straylight improvement after lens replacement was assessed by evaluation of preoperative and postoperative values. The age effect was incorporated to determine a model for straylight improvement.

Results

The mean postoperative straylight value derived from 16 studies (1869 eyes) was 1.21 log units ±0.21 (SD). Age dependence could be assessed from 13 studies (1533 eyes), resulting in the straylight age-norm curve in pseudophakic eyes as follows: Straylight value = 0.0044 x age + 0.89 with ±0.42 log units of 95% confidence interval. A strong correlation was observed between preoperative straylight and its improvement after lens extraction, yielding the following relationship: Straylight improvement = 1.04 x preoperative straylight value - 0.006 x age - 0.84.

Conclusion

A norm for straylight in the pseudophakic eye was developed that is considerably different from the previously published norm for the phakic eye. The new pseudophakic norm can be used clinically to predict the straylight value after lens replacement and as a reference criterion for clinical studies.

INTRODUCTION

The influence of light scattering on visual quality has been studied since the beginning of the 20th century. This phenomenon was first described as a veil of light over the retina by Cobb.[1] Light scatter is produced by small inhomogeneities in the eye's optical media due to variations in the refractive index. It results in the visual effect of light radiation around bright sources of light, called straylight. Straylight causes glare and other visual disturbances.[2] Almost 10% of the incoming light is scattered in young normal eyes.[3] Straylight remains stable until the fifth decade of life. Above the age of 50 years, however, a considerable increase is observed. Because of senile processes affecting the crystalline lens, straylight increases 2-fold at 65 years and is tripled by the age of 77 years for eyes with good visual acuity.[4] Increased straylight can lead to severe functional difficulties, such as disability glare, hazy vision, and decreased color sensitivity.[5] Many ophthalmologic conditions have been studied for their effect on straylight.[6] For example, a considerable increase in straylight can be observed as a consequence of corneal dystrophies,[7] cataract,[8] vitreous turbidity,[9] posterior capsule opacification (PCO),[10,11] and intraocular lens (IOL) opacity.[12]

Intraocular straylight is caused by light scattered toward the retina (forward scatter). Some part of the light is scattered backward, as observed with techniques such as biomicroscopy and Scheimpflug imaging; however, the relationship between forward scatter and backscatter is weak.[13] Therefore, these techniques are inadequate to assess straylight. Similarly, visual acuity and contrast sensitivity cannot be used to assess the amount of straylight in the human eye.[4,14] Straylight can be measured with dedicated instrumentation such as the clinically available C-Quant instrument (Oculus).[A] This device delivers a functional parameter, called log(s); a 0.1 increase in the log(s) value has more or less the same importance as loss of 1 line on the logMAR chart. This instrument has been shown to have good reliability and repeatability.[15–17]

In the management of cataract, visual acuity is still considered the primary criterion for quality of vision.[18] However, disability glare has been accepted as a criterion as well.[19,20] Because straylight increases with age, a phakic norm curve has been defined[4] to be used as reference in clinical practice as well as in clinical studies. In cataract cases, straylight can increase far above the norm. Cataract surgery has proved to be effective in reducing straylight even in cases of "clear lenses."[21] However, van der Meulen et al.[22] recently found that almost 15% of healthy cataract patients after uneventful lens replacement had no change or an increase in straylight when decision-making involved only visual acuity. This can result in postoperative dissatisfaction even though visual acuity is good. To avoid disappointment after crystalline lens extraction, it is desirable to know what straylight value can be expected in pseudophakic eyes. Thus, a pseudophakic norm curve is needed in addition to the phakic norm. This norm curve can also serve as reference for clinical studies of pseudophakic eyes.

The objectives of this study were to determine a pseudophakic norm for straylight as a new reference and to study the predictability of straylight improvement after cataract surgery. To achieve this goal, a comprehensive literature review and a cross-study data analysis were performed.

METHODS

This study included 2 parts. First, a comprehensive review was performed to assess normal straylight values as a function of age in pseudophakic eyes. Second, changes in intraocular scatter after crystalline lens replacement were evaluated by analyzing raw data from available studies.

Comprehensive Review

Eligibility Criteria

A literature examination was performed without language restrictions and encompassing all studies reporting straylight values obtained with the natural pupil using the C-Quant instrument after uneventful phacoemulsification and IOL implantation. There were no limitations with regard to age, sex, or race of the participants. Studies were excluded that enrolled patients with PCO, previous laser posterior capsulotomy, visible disturbances of the IOL, ophthalmic comorbidity, or a history of ocular surgery (excluding natural lens extraction). Data with an expected standard deviation of 0.12 log units or less were deemed reliable and used for analysis.[17]

Review Process

The scientific databases PubMed, Proquest, Embase, Medline, and Google Scholar were screened using the following keywords: C-Quant, intraocular lens, and straylight. **Figure 1** shows the results of this screening and further selection of papers.

For studies with overlapping datasets, the article containing the largest population was used. In the case of deficient data concerning the log(s)–age linear regression, the respective authors were contacted. If a response was not obtained, GSYS2.4 software[B] was used to extract missing data from the published plots. Sixteen studies fulfilled the eligibility criteria and were included in the numerical analysis. **Figure 2** shows the details of the data used to determine the pseudophakic norm.

A linear regression equation describing the dependence of straylight on age was published in 2 articles.[11,23] To collect additional information, a request was sent to the corresponding authors of the other papers. In response, raw data were received from 6 authors[4,21,22,24–26]; 3 others[27–29] delivered their linear regression equation that had not been

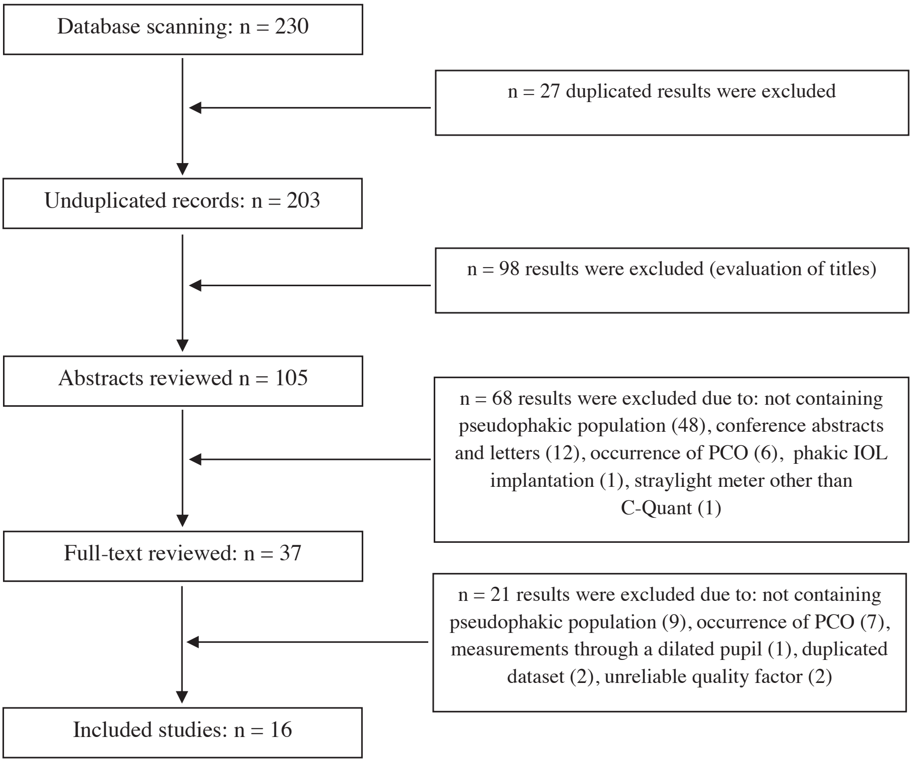

Figure 1. Flow diagram of systematic literature review (IOL=intraocular lens; PCO=posterior capsule opacification).

described in the article. No answer was obtained for 5 studies. The necessary data could be extracted from the published plots of 2 of these papers.[30,31] The remaining articles[32–34] were not used to develop the pseudophakic norm.

Breakeven Point as a Function of Age

To study actual straylight improvement after cataract surgery, both preoperative and postoperative values are needed. For this purpose, raw data were received from the authors of 3 different papers.[21,22,25] Analysis of the complete datasets from these studies led to the development of a computational model of straylight improvement after crystalline lens replacement. Improvement was defined as preoperative log(s) minus postoperative log(s), after which the relationship between preoperative straylight and its improvement was studied. The preoperative log(s) value for which improvement crosses the value zero was called the breakeven point. The breakeven point gives the 50% probability criterion to achieve a postoperative enhancement or deterioration of intraocular scatter. To incorporate the influence of aging, the calculation was performed for different decades of life. The approval for using the raw clinical data was obtained from the original authors.

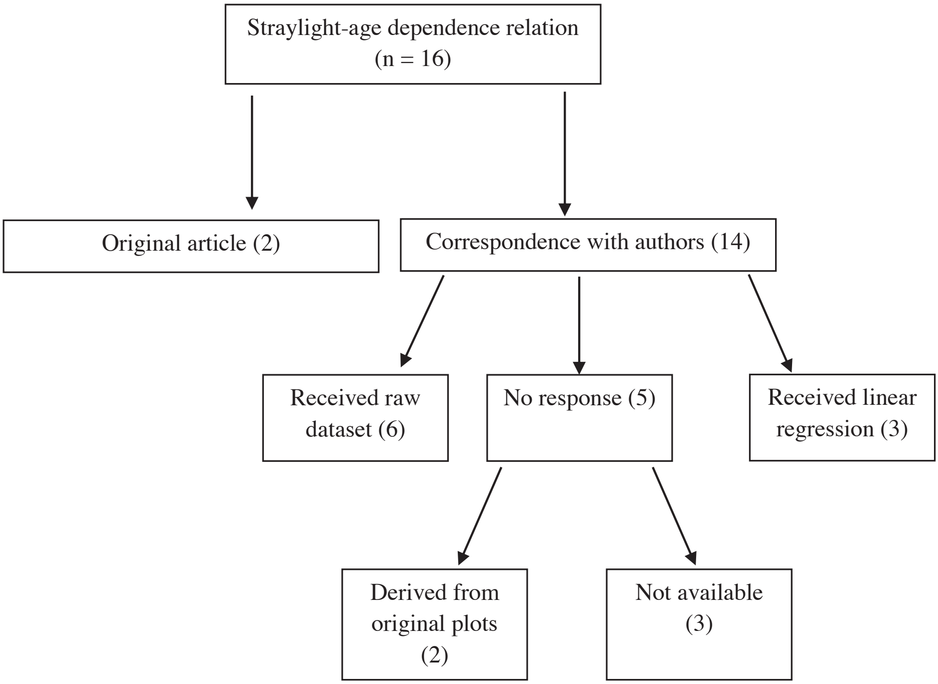

Figure 2. Data-acquisition process.

Statistical Analysis

Simple linear regression analysis describing straylight value log(s) as a function of age was calculated with Excel software (2007, Microsoft Corp.). For articles in which different IOLs were studied, the age dependency was assumed to be the same for all IOLs. To calculate the pseudophakic reference curve, a weighted average of each linear regression equation per study was performed. The raw data supplied by the original authors or the plots analysis was used to determine the 95% confidence interval (CI).[4,11,21–26,28,30,31]

To study the consistency of the new pseudophakic reference curve, it was compared to each of the 16 collected articles. The cross-validation technique was applied to avoid the influence of a particular result. The reference log(s) was calculated based on the mean age of the population in the individual study. The hypothetical control group was used to compare its result with the published log(s) value. To this end, a forest plot was created using Comprehensive Meta-Analysis software (version 2.0, Biostat, Inc.). Homogeneity was assessed by calculating the chi-square value. The difference in means (±95% CI) was used to assess effect size. Because age differences between studies induced heterogeneity, the random-effect model was chosen. The significance level was set at a P value less than 0.05.

Because both preoperative and postoperative straylight values have an uncertainty, Deming regression analysis was used to calculate the breakeven point. To improve accuracy, the slope was derived by analysis of the entire population, whereas constants and R^2 coefficients were calculated for different decades of life separately.

RESULTS

Comprehensive Review

As explained in the Methods, 16 reports fulfilled the eligibility criteria. **Table 1** shows a summary of their outcomes with the time of follow-up visits and information on the implanted IOLs.

The evaluation was of 1869 eyes. The mean age of the patients was 68 years ±9 (SD), and the mean straylight value was 1.21 ±0.21 log units (range 0.58 to 2.13 log units). **Figure 3** shows the log(s)–age linear regression as well as centers of gravity for each study.

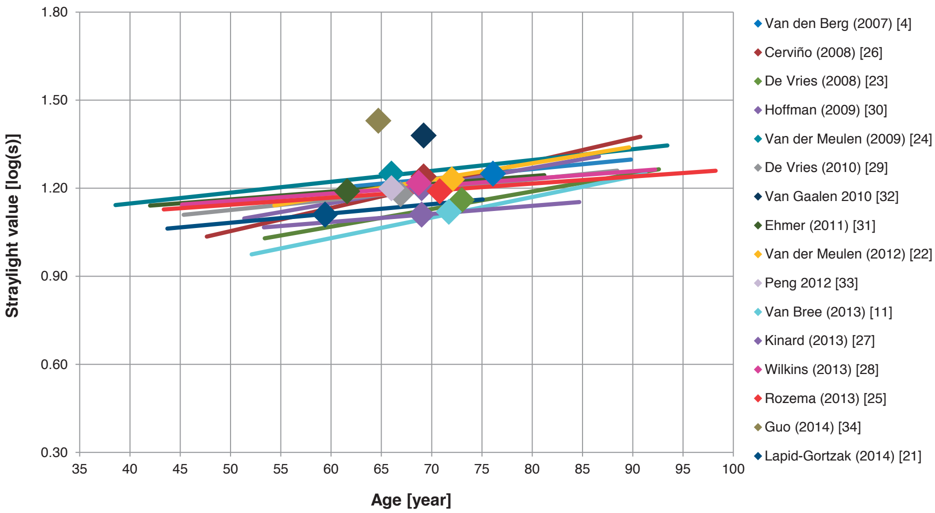

Figure 3. Linear model of log(s)-age dependency for the 13 included articles (solid lines). For each study, the plotted line is centered on the study's mean age and has a length of ±1.96 x SD of the respective age distribution. For 3 studies the regression line was not available. The diamonds represent the centers of gravity of all 16 articles included.

Pseudophakic Norm

The pseudophakic norm curve was based on 13 studies (1533 eyes). It reads:

$$\text{Straylight value} = 0.0044 \times \text{age} + 0.89$$

Table 1. Overview of published data (unless otherwise noted) in the 16 included studies.

First Author (Year)	N	Mean Age (Y) ± SD	Log(s) Mean ± SD	Log(s) Range	FU(Mo)	IOL Model*	Log(s)-Age Dependency
Van den Berg[4] (2007)	220	76 ± 7	1.25 ± 0.22	0.61, 1.95	>1	Unknown	log(s) = 0.003 × age + 1.00†
Van Bree[11] (2013)	99	72 ± 10	1.12 ± 0.19	0.58, 1.59	>6	Unknown	log(s) = 0.007 × age + 0.61
Van der Meulen[12] (2009)	56	66 ± 14†	1.25 ± 0.27†	0.68, 2.13	>2	Acrysof SA60AT/SN60WF	log(s) = 0.004 × age + 1.00†
Van der Meulen[12] (2009)	32	73 ± 9	1.24 ± 0.24	0.80, 1.68	>2	Thinoptx IOL/Acri.Smart48	log(s) = 0.008 × age + 0.66†
Cervino[15] (2008)	35	66 ± 12	1.24 ± 0.30	0.93, 1.97	>6	Rezoom/Acrysof Restor SN60D3	log(s) = 0.008 × age + 0.66†
Lapid-Gortzak[21] (2014)	160	59 ± 8	1.11 ± 0.16	0.76, 1.63	>3	SN60WF/AT Lisa 809M/Mplus LS-313/Restor SN6AD1/SeeLens MF	log(s) = 0.003 × age + 0.92†
Van der Meulen[22] (2012)	309	72 ± 9	1.23 ± 0.16	0.64, 1.82†	NA	Acrysof SN60WF	log(s) = 0.006 × age + 0.84†
De Vries[23] (2008)	44	71 ± 9	1.10 ± 0.19	0.78, 1.60	>6	Acrysof SA60AT	log(s) = 0.006 × age + 0.77
De Vries[23] (2008)	60	75 ± 10	1.20 ± 0.16	0.86, 1.61	>6	Acrysof Restor SA60D3	log(s) = 0.006 × age + 0.77
Rozema[25] (2013)	81	71 ± 14	1.19 ± 0.21	0.73, 1.68	>6	89A Morcher	log(s) = 0.002 × age + 1.02†
Kinard[27] (2013)	70	69 ± 8	1.11 ± 0.19	0.78, 1.76	>6	Acrysof SN6WF	log(s) = 0.003 × age + 0.92§
Wilkins[28] (2013)	83	69 ± 12	1.18 ± 0.28§	0.55, 1.92‡	>4	Akreos AO	log(s) = 0.003 × age + 0.89§
Wilkins[28] (2013)	82	67 ± 11	1.21 ± 0.29§	0.62, 2.00‡	>4	Tecnis ZM900	log(s) = 0.003 × age + 0.89§
De Vries[29] (2010)	47	65 ± 10	1.19 ± 0.19	0.85, 1.79‡	>6	Acrysof Restor SN6AD3	log(s) = 0.003 × age + 0.95§
De Vries[29] (2010)	45	68 ± 11	1.16 ± 0.16	0.89, 1.61‡	>6	Acrysof Restor SN60D3	log(s) = 0.003 × age + 0.95§
Hofmann[30] (2009)	40	72 ± 8‡	1.20 ± 0.24‡	0.75, 1.87†	>18	SA60AT	log(s) = 0.006 × age + 0.79‡
Hofmann[30] (2009)	40	68 ± 9‡	1.20 ± 0.20‡	0.84, 1.65†	>18	Acrysof Restor SA60D3	log(s) = 0.006 × age + 0.79‡
Ehmer[31] (2011)	10	60‡ ± 14‡	1.12 ± 0.12‡	0.95, 1.35	>3	ReZoom	log(s) = 0.003 × age + 1.03‡
Ehmer[31] (2011)	10	59‡ ± 10‡	1.32 ± 0.22‡	1.04, 1.76	>3	Tecnis ZM900	log(s) = 0.003 × age + 1.03‡
Ehmer[31] (2011)	10	65‡ ± 7‡	1.14 ± 0.19‡	0.87, 1.51	>3	Mplus LS-313	log(s) = 0.003 × age + 1.03‡
Van Gaalen[32] (2010)	29	69 ± 10	1.38 ± 0.26	NA†	>1.5	Tecnis Z9000	NA
Van Gaalen[32] (2010)	29	69 ± 10	1.38 ± 0.25	NA†	>1.5	Sensar AR40e	NA

Table 1. Overview of published data (unless otherwise noted) in the 16 included studies. (continued)

First Author (Year)	N	Mean Age (Y) ± SD	Log(s) Mean ± SD	Log(s) Range	FU(Mo)	IOL Model*	Log(s)-Age Dependency
Peng[33] (2012)	102	67 ± 9	1.16 ± 0.23	NA†	>6	Acrysof SN60WF	NA
Peng[33] (2012)	100	66 ± 9	1.23 ± 0.21	NA†	>6	Acrysof Restor SN6AD1	NA
Guo[34] (2014)	24	67 ± 7	1.47 ± 0.22	0.93, 1.88	>1	Sensar AR40e	NA
Guo[34] (2014)	28	63 ± 10	1.37 ± 0.24	0.95, 1.82	>1	Hexavision HQ201hep	NA
Guo[34] (2014)	24	65 ± 8	1.45 ± 0.23	0.96, 1.87	>1	Henan PC156C55	NA

FU = follow-up; IOL = intraocular lens; NA = not available

*BIL (Type 89A, Morcher GmbH, Germany); Acri.Smart48 (Carl Zeiss Meditec, Jena, Germany); Acrysof Restor SN60D3 (Alcon Laboratories, Fort Worth, TX, USA); Acrysof Restor SN6AD1 (Alcon Laboratories, Fort Worth, TX, USA); Acrysof Restor SN6AD3 (Alcon Laboratories, Fort Worth, TX, USA); Acrysof SA60AT (Alcon Laboratories, Fort Worth, TX, USA); Acrysof SN60WF (Alcon Laboratories, Fort Worth, TX, USA); Akreos AO (Bausch & Lomb, Rochester, NY, USA); AT Lisa 809M (Carl Zeiss Meditec, Jena, Germany; PC156C55 (Henan Universe Intraocular Lens Research and Manufacture Co, Henan, China); HQ201hep (Hexavision, Paris, France); Mplus LS-313 (Oculentis GmbH, Berlin, Germany); Restor SN60D3 (Alcon Laboratories, Fort Worth, Texas, USA); Rezoom (Advanced Medical Optics, Santa Ana, California, USA); SeeLens MF (Hanita Lenses RCA Ltd., Kibbutz Hanita, Israel); Sensar AR40e (Advanced Medical Optics, Santa Ana, California, USA); Tecnis Z9000 (Advanced Medical Optics, Santa Ana, California, USA);Thinoptx IOL (ThinOptX Inc, Abrindon, Virginia, USA)

†Derived from) analysis of raw records

‡Derived published plots

§Derived correspondence with the authors

The 95% CI derived from 1366 raw records was ±0.42 log units. **Figure 4** shows the new reference curve and the 1366 individual postoperative log(s) values from available studies.

The above norm function recalculated by the cross-validation technique was applied to compare the outcomes of the included papers. Heterogeneity was observed with $I^2 = 85\%$ ($P < .05$); therefore, the random-effect model was used. Eleven of the 16 evaluated studies did not show statistically significant differences in the mean log(s) value compared with the reference curve. **Figure 5** shows the pooled study's distribution as a graph. The mean overall difference was -0.02 ±0.02 log units; however, the effect was not statistically significant (P = .26).

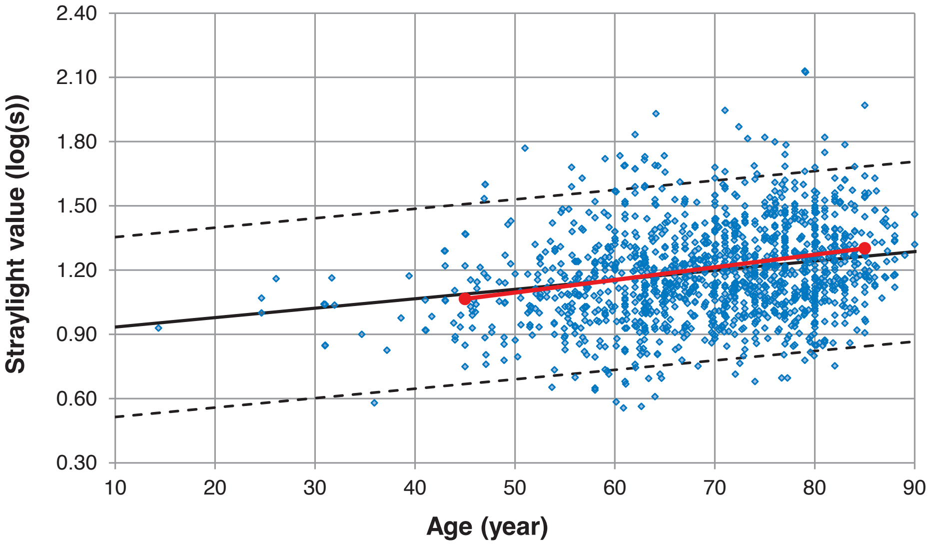

Figure 4. Intraocular scatter as a function of age in pseudophakic eyes (diamonds). The solid blackline represents the straylight pseudophakic norm with 95% CI (dashed lines). The solid red line shows the break-even point for age dependency.

Breakeven Point in Relation to Age

For 558 records, individual postoperative and preoperative straylight values were available. They were partitioned according to patient age in 5 decades of life from 40 to 90 years. Five eyes were excluded from the analysis because they did not fall into any of the age bands. **Figure 6** shows the difference between preoperative and postoperative straylight values as a function of preoperative straylight.

The reference curve reads

Straylight improvement = 1.04 x preoperative straylight value - 0.006 x age - 0.84 (R^2= 0.59, P<.05). **Table 2** shows detailed information on preoperative and postoperative straylight, including breakeven points for different decades of life. **Figure 4** is a graph of the breakeven point increase with patient age.

Study name	Difference in means	Standard error	Lower limit	Upper limit	p value
Van den Berg (2007)	-0.03	0.02	-0.07	0.01	0.14
Cervino (2008)	-0.05	0.04	-0.13	0.03	0.21
De Vries (2008)	0.05	0.03	-0.00	0.10	0.06
Hoffman (2009)	-0.01	0.03	-0.08	0.06	0.77
Van der Meulen (2009)	-0.08	0.05	-0.17	0.01	0.08
De Vries (2010)	0.00	0.03	-0.06	0.06	1.00
Van Gaalen (2010)	-0.18	0.04	-0.27	-0.09	**0.00**
Ehmer (2011)	-0.03	0.05	-0.13	0.07	0.57
Van der Meulen (2012)	-0.03	0.02	-0.06	0.00	0.06
Peng (2012)	-0.02	0.02	-0.06	0.02	0.35
Van Bree (2013)	0.09	0.03	0.03	0.15	**0.00**
Kinard (2013)	0.09	0.03	0.02	0.16	**0.01**
Wilkins (2013)	-0.03	0.03	-0.08	0.03	0.31
Rozema (2013)	0.01	0.03	-0.05	0.07	0.76
Guo (2014)	-0.25	0.04	-0.32	-0.18	**0.00**
Lapid (2014)	0.05	0.02	0.01	0.09	**0.02**

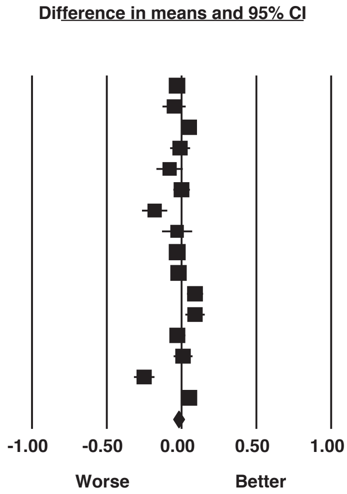

Figure 5. Forest plot characterizing differences between studies and computational age-matched control groups. The hypothetical straylight value was calculated based on the mean age in each article. Of 16 studies, 11 did not show a statistically significant difference in means, whereas 5 indicated abnormal results. Boldfaced P values indicate statistical significance. For more details about the computational technique and the discussion of the outcomes, please refer to the Discussion section (CI = confidence interval).

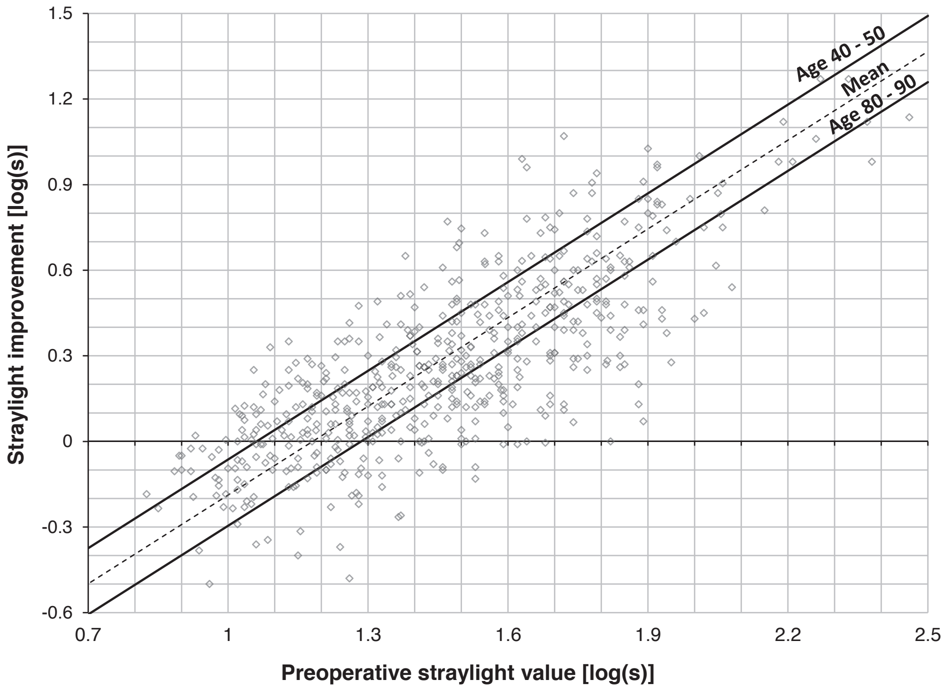

Figure 6. Improvement in straylight after crystalline lens exchange. The dashed line represents the mean rate, while the solid lines indicate the age effect. The upper line corresponds with the age range 40 to 50 years and the lowest line with the age range 80 to 90 years.

Table 2. Preoperative and postoperative straylight values and postoperative improvement for 553 eyes stratified over 5 decades of age.

	Age (Y)				
Parameter	40 to 50 (n = 23)	50 to 60 (n = 90)	60 to 70 (n = 160)	70 to 80 (n = 193)	80 to 90 (n = 87)
Preoperative straylight value					
Mean ± SD	1.21 ± 0.34	1.29 ± 0.32	1.41 ± 0.27	1.57 ± 0.25	1.57 ± 0.25
Range	0.89, 2.33	0.83, 2.26	0.93, 2.06	0.96, 2.46	0.94, 2.38
Postoperative straylight value					
Mean ± SD	1.06 ± 0.16	1.12 ± 0.20	1.17 ± 0.17	1.24 ± 0.20	1.27 ± 0.21
Range	0.76, 1.43	0.64, 1.68	0.78, 1.67	0.68, 1.82	0.75, 1.82
Straylight improvement					
Mean ± SD	0.16 ± 0.37	0.17 ± 0.33	0.24 ± 0.27	0.33 ± 0.31	0.29 ± 0.28
Range	–0.35, 1.27	–0.32, 1.12	–0.36, 1.03	–0.50, 1.27	–0.38, 0.98
Improvement rate* (%)	61	63	81	86	81
Breakeven point					
Log(s)	1.06	1.13	1.18	1.26	1.29
R^2	0.81	0.64	0.56	0.58	0.42
P value	<.05	<.05	<.05	<.05	<.05

*Frequency of values above zero (no change)

DISCUSSION

In the present study, a normative reference curve for straylight in pseudophakic eyes was established. This was based on data from 13 publications. We believe that the creation of the straylight pseudophakic norm is advantageous to the ophthalmic practice as well as to clinical studies. Several authors have used the phakic straylight reference curve in their research to compare the straylight value in pseudophakic eyes.[10,21,24,26,29,30] However, when comparing the pseudophakic curve with the phakic curve, there are important differences. Straylight levels are stable in young phakic eyes and increase considerably above the age of 50 years; thus, the phakic reference is approximated by a logarithmic function. The present study shows that in pseudophakic eyes, the relationship between straylight and age is linear. In addition, the phakic reference shows a mean increase in straylight of 0.15 log units per decade,[4] whereas our current findings show a 0.044 log unit increase per decade after crystalline lens replacement. Therefore, evaluating postoperative results using age matched noncataractous phakic subjects could lead to misjudgment.

The new reference norm was compared with the published log(s) values in the studies included in the analysis. The pseudophakic normative curve derived from 13 articles is close to the real values in most datasets. As can be seen in **Figure 5**, in 11 studies there was no significant difference in the mean straylight value between the study and the norm.

However, 5 studies did not seem to comply, of which 3 had somewhat better straylight levels than the norm. We think this might be related to patient selection. Van Bree et al.[11] Lapid-Gortzak et al.,[21] and Kinard et al.[27] enrolled only subjects with a high-quality state of their eyes. The 2 other studies reported relatively high average straylight values, of which Guo et al.[34] showed the highest. The reason for the high straylight numbers in the study by Guo et al.[34] might be that the straylight measurements were performed in a dark room with a subsequently large pupil diameter. Van der Meulen et al.[24] and van Gaalen et al.[35] separately found that intraocular scatter is closely related to pupil diameter in pseudophakic eyes. Their findings show that 1.0 mm of visible capsulorhexis remnant induces 0.52 log units of additional straylight. Nevertheless, Guo et al.[34] stressed that they found no differences in straylight values between natural pupils and dilated pupils. To clarify whether the natural pupil's response to scotopic light conditions can affect straylight measurements, additional studies are needed. The mean straylight value reported by van Gaalen et al.[32] was also statistically significantly higher than the normative line. However, we could not find a potential explanation for this difference.

Figure 6 shows that the relationship between the preoperative straylight value and its improvement after IOL implantation was different in the various age groups. The upper lines and the lower lines correspond to the age ranges 40 to 50 years and 80 to 90 years, respectively. This suggests that the older the patient is, the higher the breakeven point and that more preoperative straylight is required to achieve postoperative improvement. The age effect was rather clear and corresponds with approximately a doubling of the amount of straylight needed to obtain postoperative improvement between 40 years and 90 years. Thus, these findings imply a necessity of age classification of the breakeven point. Moreover, the breakeven point values in **Table 2** are close to the reference norm (**Figure 4**). Therefore, the established reference norm might be considered a predictive feature to improve the clinical decision-making process before crystalline lens exchange.

A considerable improvement in the amount of straylight after crystalline lens replacement (mean 0.27 ±0.30 log units) was observed in the subpopulations (see **Table 2**). However, there was an evident dependency on age. Approximately 40% of patients younger than 60 years had an increase or no change in ocular straylight after surgery. Roughly one half of these subjects had refractive lens exchange (RLE). These results suggest that when considering lens extraction in healthy subjects, preoperative straylight levels should be taken into account. On the other hand, patients older than 60 years had a mean clinical improvement exceeding 80%. Therefore, the probability of improving the straylight value following lens extraction increases with age. However, it is significant that the correlation coefficient (R^2) declined with age. The highest predictive power was observed for patients in their 40s ($R^2 = 0.81$); it gradually decreased to $R^2 = 0.42$ for patients in their 80s. The strongest predictability was in the subpopulation younger than 60 years, with a greater chance of negative results. Thus, the proposed model can help during preoperative planning to decrease the likelihood of visual disabilities after lens extraction.

The results presented in **Table 2** show that preoperative straylight values in the older subjects were higher than in the younger ones. This might suggest that in patients with cataract, preoperative straylight gradually increases with age in the same way as in normal phakic eyes. However, we think this is not the case. When Lapid-Gortzak et al.'s[21] refractive patients were excluded and only the van der Meulen et al.[22] and Rozema et al.[25] cataract studies were used, there was no such effect. In other words, in those cataract studies, young subjects were granted surgery only when, on average, their straylight was as high as in older subjects. Speculatively, this might be related to a reluctance to operate on young eyes despite significant hindrance from straylight compared with that in eyes of age-equivalent peers.

According to global statistics, approximately 10 million people annually have crystalline lens replacement because of the presence of cataract.[36] This number is increased by RLE performed to correct a refractive error or overcome presbyopia. The popularity of these practices is associated with a great variety of implanted IOLs. This must be realized when considering the general normative straylight function established in the present paper. However, the studies that we analyzed already had a great variety in the type of IOLs and showed relatively consistent behavior in the age-dependency of straylight, as shown in **Figure 3**. The effect of the type of IOL on straylight has been studied in the literature, especially for diffractive multifocal IOLs versus monofocal IOLs.[23,26,28,30,33] Optically, these IOLs are very different with respect to design and light distribution[37,38]; however, the literature has not been clear about the differences in straylight. De Vries et al.[23] and Peng et al.[33] found a considerable increase in straylight in a multifocal IOL subpopulation compared with their monofocal IOL counterparts. In contrast, Cerviño et al.,[26] Wilkins et al.,[28] and Hofmann et al.[30] report insignificant differences between those groups. Some authors speculate that constriction of the pupil during measurements could be an explanation for the lack of effect.[26] This might be in line with *in vitro* studies testing multifocal IOLs, underlining that the aperture has a substantial impact on optical performance.[38,39] Clinical reports of the effect of pupil size on straylight after multifocal IOL implantation have not been published until now; thus, further studies are needed to determine its potential effects.

In the current study, a reference curve for straylight values in normal pseudophakic eyes is presented. The new norm can be used in research as a reference criterion and clinically, in managing cataract patients for predicting the postoperative straylight level. The proposed approach might enhance patient selection as well as minimize the potential for disability glare and patient dissatisfaction.

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