Retroillumination versus Reflected-Light Images in the Photographic Assessment of Posterior Capsule Opacification

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PURPOSE. To investigate the relative merit of retroillumination and of reflected light slit-lamp-derived photographs in the assessment of the opacification of the posterior lens capsule.

METHODS. Retroillumination and slit-lamp-derived reflected-light photographs were taken on 23 consecutive eyes with posterior capsule opacification (PCO) in uncomplicated pseudophakia. Subjective grading was performed on both types of photographs to evaluate the extent and density of posterior capsular opacification. Best-corrected visual acuity (BCVA) before and after YAG laser capsulotomy was used to assess the impact of capsular opacification on visual function.

RESULTS. After capsulotomy all patients attained a BCVA $\geq 46$ letters ($\geq 20/32$) with a mean increase of 25 letters, indicating that PCO was the cause of visual impairment in these patients. The relative capacity of retroillumination and of reflected-light photographs to adequately capture the extent and the severity of posterior capsule opacification varied considerably. Reflected-light images, in addition to frequently producing higher severity scores for the opacity than retroillumination photographs, in 4 of 23 eyes (17.4%) proved to be the only technique able to document the presence of PCO.

CONCLUSIONS. Our results indicate that, with respect to retroillumination images, reflected-light photography has an increased ability to adequately capture the presence and the severity of PCO and that the use of only retroillumination images may lead to its underestimation. This may be relevant to clinical studies aiming to evaluate incidence and progression of this condition. (Invest Ophthalmol Vis Sci. 2000;41:3074–3079)

Posterior capsule opacification (PCO) is the most frequent complication of extracapsular cataract surgery and its prevalence has been reported by some studies to even approach 50%.1–3 The condition is successfully treated by YAG laser capsulotomy, a procedure which is not without complications and is associated with considerable costs that may limit its use in countries with limited economic resources. It has been estimated that in the United States approximately 25% of patients undergo this procedure within 2 years of cataract surgery.4 PCO is caused by residual lens epithelial cells that migrate to the posterior capsule, resulting in its opacification, in the formation of striae and folds, pearl-like opacities, and in decreased visual acuity.5,6 The high prevalence of PCO explains the efforts directed to better understand the factors influencing its development and progression as well as the search for surgical techniques, IOL material and design, or drugs able to prevent proliferation and migration of residual lens epithelial cells.

Given the relative subjectivity of the clinical grading of PCO at the slit-lamp, the availability of photographic techniques able to reliably assess presence and severity of PCO and to document its progression over time is crucial in these types of studies. To be adequate for research use, a photographic grading system should not only be reproducible but should also use a standardized procedure for image acquisition to allow comparison over time.

Techniques based on retroillumination images and subjective grading or automated image analysis have been developed by Tetz et al.,7 Pande et al.,8 and by Friedman et al.9 Reproducible quantification of PCO,7,8 good correlation with clinical assessment at the slit-lamp, and the ability to document progression over time9 have been reported.

Scheimpflug slit-lamp photography has been applied10–12 to quantify PCO by averaging the density values of the posterior capsule obtained with the EAS-1000 system (Anterior Eye Segment Analysis System; Nidek, Gamamori, Japan) on images taken on four meridians (0°, 45°, 90°, and 135°). This system provides good cross-sectional, very narrow slit-lamp images of the posterior capsule but has the disadvantage of requiring multiple images on different meridians to reliably estimate the extent of the opacity.

During evaluation of posterior capsule opacification in clinical studies on cataract using both clinical and photographic techniques, we noticed the relative frequency of a disagreement in the ability of slit-lamp and of retroillumination...
images to quantify PCO. In this article we report a series of 23 consecutive cases requiring YAG laser capsulotomy for PCO, documented with both retroillumination and slit-lamp–derived reflected-light photographs, suggesting that the use of only retroillumination images may significantly underestimate presence and severity of PCO.

**MATERIALS AND METHODS**

**Patients**

Patients were persons requiring YAG laser capsulotomy for PCO after having received uncomplicated extracapsular cataract extraction and in the bag IOL implantation in this Institute. Twenty-three consecutive patients (9 men and 14 women) aged 22 to 94 years (71.7 ± 16.4 years) received retroillumination and slit-lamp–derived reflected-light photographic documentation of PCO before YAG laser capsulotomy. Best-corrected visual acuity (BCVA) was measured before and 3 weeks after capsulotomy by counting the number of letters correctly identified on the ETDRS chart at 4 meters.

The study protocol was approved by the University of Parma institutional review board in accordance with the tenets of the Declaration of Helsinki.

**Photographic Techniques**

Retroillumination photographs were taken after attaining maximal pupil dilation. A modified Neitz CT-R cataract camera (Kowa Optimed Inc., Torrance, CA) and standardized parameters (professional Ektachrome E200 color slide film, flash intensity set to position 4, aperture setting 1, orange contrast filter on) have been used, according to the Age-Related Eye Disease Study (AREDS) to obtain a better fixation control and

**FIGURE 1.** Retroillumination (left) and reflected-light (right) standard photographs used for PCO subjective density grading. Numbers indicate the score of PCO density and refer to the area within the circle. Photographs on each row do not correspond to the same eye.

**FIGURE 2.** Intraobserver agreement on PCO grading (PCO index) for retroillumination photographs; 30 replicate gradings.

**FIGURE 3.** Intraobserver agreement on PCO grading (PCO index) for reflected-light photographs; 30 replicate gradings.
Grading of the Extent and Density of PCO

Extent of PCO was subjectively assessed on retroillumination and on reflected-light (slit-lamp) photographs by using the same grid used to grade cortical and posterior capsular opacities according to the AREDS cataract grading system.\(^{13}\) The grid is formed by three consecutive circular subfields each representing 5% of the central 2-mm radius circle and each line has 5 letters, a LogMAR score can be created by assigning 0.02 LogMAR units for each letter correctly identified.\(^{16}\)

A similar grid, scaled to compensate for the different magnification factor, was used to assess PCO on slit-lamp-derived images with an inner circle corresponding to a 2-mm circle at the eye level. The same procedure described for the retroillumination photographs was then used to grade PCO extent on the reflected-light images.

Density of the opacity within the same 2-mm radius circle was subjectively estimated on retroillumination and on reflected-light images by comparison with a five-step density scale that uses the two sets of photographic standards reproduced in Figure 1. The intensity of dark areas in retroillumination and of bright areas in reflected-light photographs were considered regardless of the type (pearl-like or fibrosis) of PCO. An average density of the area involved by the PCO was then estimated by assigning a score from 0 to 4.

Retroill., retroillumination.

*BCVA is expressed as the total number of letters correctly identified. Since there is 0.1 LogMAR unit difference between lines in ETDRS charts and each line has 5 letters, a LogMAR score can be created by assigning 0.02 LogMAR units for each letter correctly identified.\(^{16}\)

†PCO index is a combined index of severity which includes both density and extension, and is calculated multiplying the density score by the percent area covered by PCO within the 2-mm circle.

To help subjective assessment of percent involvement, circular subfields each representing 5% of the central 2-mm radius circle were used in the grading procedure, resulting in estimates nearly always progressing in 5% steps.

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On both retroillumination and slit-lamp-derived photographs a combined index of severity of the opacity, which included both density and extension (PCO index), was calculated multiplying the density score value by the percent area covered by PCO within the 2-mm circle and was used to assess reproducibility and to correlate PCO grading to functional impairment.

All photographs were graded by a single observer (MC) with a great experience with the AREDS cataract grading system and excellent intraobserver reproducibility. To assess reproducibility of PCO grading, 30 sets of retroillumination and reflected-light photographs of the same eyes, which included the study eyes, were graded and then rearranged in random order and graded again by the same observer 2 weeks later.

**Table 1.** Visual Acuity, Retroillumination, and Reflected-Light (Slit-Lamp) PCO Grading for 23 Consecutive Study Patients

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<th>Retroill. PCO % Area†</th>
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Statistical Analysis

All data were analyzed using commercial software (SPSS 8.0). Agreement was assessed by intraclass correlation and by plotting differences between paired replicates on scatter plots. For each pair of replicate grades, the difference of smaller member and higher grade was used so that all points lie above the $x = y$ line. Spearman’s coefficient was calculated to assess correlation between PCO index and BCVA.

RESULTS

On both retroillumination and slit-lamp–derived reflected-light photographs the grading showed good reproducibility. Figures 2 and 3 indicate that for the PCO index the agreement was 100% within 1 unit difference and 90% within 0.5 unit difference for the retroillumination (intraclass correlation: 0.97) and, respectively, 100% and 83% for the reflected-light photographs (intraclass correlation: 0.96).

Results for the 23 consecutive patients are summarized in Table 1. The data show that after YAG laser capsulotomy BCVA was $\geq 46$ letters (approximately 20/32) in 100% of the patients, and was $\geq 50$ letters (20/25) in 78% (18/23), with an average increase of 25 letters over precapsulotomy BCVA. This indicates that in these patients PCO was indeed the cause of the reduced visual acuity. Patients 13, 14, and 23, whose BCVA increased by only 5, 6, and 6 letters, respectively, over baseline values, showed the highest precapsulotomy BCVA scores.

Comparison of PCO grading on retroillumination and on reflected-light photographs indicates considerable variability and in some cases striking differences between the two photographic techniques. PCO density grade on the slit-lamp–derived photographs was 2 steps higher in 9 cases, 3 steps higher in 5 cases, and 4 steps higher in 1 case, with respect to the density grade on the retroillumination photographs. Similar differences were found between the two techniques when the percent area involved by the PCO was evaluated and also when the PCO index was considered. These results are summarized in Figure 4, where gradings obtained with reflected-light photography are plotted against those obtained with the retroillumination technique. In four patients (n 2, 14, 15, 21) PCO could be detected only on the reflected-light photographs and was not captured by the retroillumination images. Representative examples of these discrepancies and a case of good agreement are reported in Figure 5. Both retroillumination and

![Figure 4](image-url)  
**FIGURE 4.** Combined index of severity (PCO index) for reflected-light images plotted against PCO index for retroillumination images.

![Figure 5](image-url)  
**FIGURE 5.** Comparison of retroillumination (left) and reflected-light (right) photographs of cases of PCO. Each row reproduces images of the same eye. (A through F) Examples of three cases (patients 21, 15, 22) in which PCO was significantly captured only by reflected-light photography. The *lowermost row* (G, H) shows good detection of PCO with both photographic techniques (patient 11). *Insets* in (G) and (H) reveal good correspondence between the two photographic techniques when the negative of the reflected-light image is used for comparison.
reflected-light PCO indexes are inversely correlated with pre-capsulotomy BCVA, with $r_s = 0.502$ ($P = 0.015$) and $r_s = 0.501$ ($P = 0.015$), respectively (Fig. 6).

**DISCUSSION**

We have studied 23 consecutive cases of PCO in uncomplicated pseudophakia by means of retroillumination and of slit lamp–derived reflected-light photographs to compare the relative ability of these two imaging techniques to capture the opacification of the posterior capsule in these eyes. Our results indicate that the grading of both PCO extension and density may differ considerably with the two photographic techniques. Reflected-light images consistently produced higher severity scores for the opacity and in four cases proved to be the only technique able to document the presence of PCO. In 20 of the 23 cases BCVA increased significantly (at least two chart lines; average increase 28 letters, SD = 10.8) after YAG laser capsulotomy. In the remaining three cases the increase was at least 1 chart line. BCVA reached normal levels for the patient’s age in all participants. We have therefore indirect evidence that PCO was indeed present in these participants as removal of the obstruction along the visual axis by capsulotomy resulted in the expected visual recovery.

An ideal grading of PCO should result in measures that correlate well with the reduction of visual function induced by the opacity. Unfortunately the task of predicting the degradation of the retinal image by evaluating the morphology of the posterior capsule does not seem to be an easy one, because it is highly influenced by two major factors: the optical principles adopted to obtain PCO images and what measure is used to quantify the visual impairment caused by PCO. Also in our study the correlation of PCO gradings with BCVA, although present with both systems, has some limitations. Figure 6 shows that retroillumination images do not detect some cases of PCO even in cases of severe visual impairment, and that reflected-light images result in high severity scores even in cases with relatively well preserved BCVA.

Retroillumination and reflected-light photography use different optical principles to obtain images of the posterior lens capsule. The microstructure of the opacity is highly variable (fibrosis and/or pearls of different severity and distribution), resulting in the combination of different effects on the incident light rays, that can be refracted, reflected, absorbed, or scattered. The usual retroillumination photograph basically detects absorption of the light transmitted from the retina to the observer. Probably, this usual way of looking at PCO may result in underestimation of its negative effects on the transmission of images to the retina if the opacity behaves as a matte surface. In fact such surfaces, differently from glossy ones, have tiny imperfections that cause light to scatter still allowing good uniform transmission of light (approximating a Lambertian light source). An everyday example of this phenomenon is given by opalescent glass (as mounted in light boxes or in showers), which provides good uniform light diffusion, but highly affects the sharpness of images. The scatter of light produced by a matte surface could be better detected when using reflected rather than transmitted light. The oblique incident light beam of a slit lamp seems adequate to reveal this optical property at the level of the posterior capsule, particularly when a broad slit is used. Actually this is the same way PCO is evaluated during clinical examination, even during YAG laser treatment.

It must be noticed that in the present study some of the cases showed relatively high visual acuity before capsulotomy. Nevertheless, they complained decreased “visual function,” had significant posterior capsule opacification at clinical examination, and were considered eligible for YAG laser capsulotomy. This may indicate that visual acuity alone is probably not the most adequate measure to quantify the visual impairment caused by PCO. It is possible that the addition of contrast sensitivity and glare testing to visual function assessment could eventually result in the improvement of the correlation between morphology and function.

Our results provide evidence that retroillumination and slit-lamp–derived reflected-light photographs differ considerably in their ability to adequately capture opacification of the posterior lens capsule. This seems to be sometimes particularly evident as in four of our cases only one of the photographic techniques was able to document the existence and the severity of the opacity. These results are consistent with our previous experience with the photographic assessment of posterior capsular cataract, which suggests that the subjective clinical assessment of this type of opacity at the slit lamp, which allows the observer to examine the posterior lens surface using different orienta-
tions of the light beam, might be more accurate than using retroillumination photographs. A limitation of the present study is that we cannot exclude that by slightly changing the angle between the illumination beam and the visual axis of the eye one might, in individual cases, improve the ability of retroillumination images to capture the opacification of the posterior capsule. Nevertheless, adopting a standardized procedure seems to offer some advantages in a technique to be used for scientific and not only clinical purposes. It is also possible that the standardized AREDS settings designed to maximize image brightness, which we used for retroillumination photography, may not be optimal to visualize PCO.

In the present study we have adopted subjective grading systems of PCO for retroillumination and reflected-light photographs. It would be of interest to apply computerized image analysis procedures to obtain fully automated and objective grading of PCO for both photographic techniques.

In conclusion, our results indicate that slit-lamp–derived reflected-light photography has an increased ability to adequately capture the presence and the severity of PCO in pseudophakic eyes and that the use of retroillumination images alone may lead to its underestimation. This may be relevant to studies aiming to evaluate incidence and progression of this condition.

Although our data suggest that the reflected-light approach might be useful in documenting progression of PCO over time, the use of reflected-light imaging should be tested in longitudinal trials before this technique can be recommended.

References


