Quantitative Comparison of Posterior Capsule Opacification After Polymethylmethacrylate, Silicone, and Soft Acrylic Intraocular Lens Implantation

Hideyuki Hayashi, MD; Ken Hayashi, MD; Fuminori Nakao, MD; Fumihiko Hayashi, MD

Objective: To quantitatively compare the extent of posterior capsule opacification (PCO) after polymethylmethacrylate (PMMA), silicone, and soft acrylic intraocular lens implantation.

Patients and Methods: A total of 240 eyes from 240 patients undergoing implant surgery were randomized into 3 groups based on the type of lens implanted: PMMA, silicone, and soft acrylic. The density value of PCO in 185 eyes was quantitated approximately 2 years after surgery by a new measurement method using the Scheimpflug videophotography system.

Results: Twenty-one eyes (30.4%) in the PMMA group, 4 (5.7%) in the silicone group, and 2 (2.7%) in the acrylic group had already undergone Nd:YAG laser posterior capsulotomy. The mean ± SD PCO values were 26.3 ± 12.2 computer-compatible tape steps (CCT) in the PMMA group, 12.0 ± 8.3 CCT in the silicone group, and 16.0 ± 10.3 CCT in the acrylic group. The PCO value in the PMMA group was significantly greater than that in the silicone or acrylic group (P < .001). The visual acuity loss in the PMMA group was also greater than that in the silicone or acrylic group (P < .001).

Conclusion: Based on the PCO value and capsulotomy rate, the PCO was more extensive with the PMMA lens than with either the silicone or soft acrylic lens, which led to visual acuity loss.


Even in modern cataract surgery, posterior capsule opacification (PCO) is still the most common postoperative complication. It is well known that PCO is caused by the regeneration and extracellular matrix production of the residual lens epithelial cells. To prevent PCO, various kinds of drugs have been applied to suppress the activity of the lens epithelial cells. However, the reducing effect of these drugs on PCO remains only speculative since the quantification of PCO has yet to be established.

We recently developed a new measurement method of PCO using the Scheimpflug videophotography system. Using this method, the opacification density in the central posterior capsule area can be measured. We also confirmed this method to have an excellent intraobserver and interobserver reproducibility.

The incidence of PCO has also been reported to differ based on the optic material of the implanted intraocular lens (IOL) with regard to the Nd:YAG capsulotomy rate. Recently, surgeons have reported less PCO with soft acrylic IOLS because of its adhesive quality to the lens capsule.

The purpose of this study was to quantitatively compare the extent of PCO after polymethylmethacrylate (PMMA), silicone, and soft acrylic lens implantation. We also compared the visual acuity loss due to PCO between the eyes that were implanted with 3 different kinds of IOLs.

Of the 240 enrolled eyes, 28 were lost to follow-up. Therefore, 212 eyes remained for the analysis. The patient demographics are shown in Table 1. The mean ± SD patient age was 68.9 ± 9.1 years with a range of 52 to 93 years, and the patients included 88 men and 124 women. No statistically significant differences were found regarding age, sex, or the ratio of the left and right eyes between the 3 groups. In the first examination, after a full mydriasis at 1 week after surgery, all IOLs were confirmed to be accurately implanted in the capsular bag.

Of the 212 eyes, 21 eyes (30.4%) in the PMMA group, 4 (5.7%) in the silicone group, and 2 (2.7%) in the acrylic group had already undergone Nd:YAG laser posterior capsulotomy. The mean ± SD PCO values were 26.3 ± 12.2 computer-compatible tape steps (CCT) in the PMMA group, 12.0 ± 8.3 CCT in the silicone group, and 16.0 ± 10.3 CCT in the acrylic group. The PCO value in the PMMA group was significantly greater than that in the silicone or acrylic group (P < .001). The visual acuity loss in the PMMA group was also greater than that in the silicone or acrylic group (P < .001).
**PATIENTS AND METHODS**

Two hundred forty cataractous eyes in 240 patients who were scheduled to undergo phacoemulsification and IOL implant surgery were originally enrolled in this study. The preoperative exclusion criteria were as follows: cataracts with causes other than age-related changes, a history of ocular surgery or inflammation, eyes with pseudoxefoliation syndrome or retinal morbidity, eyes in diabetic patients, and eyes with a small pupil diameter after a full dilation measuring less than 6.0 mm. All enrolled eyes were randomly assigned by the sealed envelope method to 1 of the 3 groups based on the type of IOL and included the PMMA group (MZ60BD, Alcon Surgical, Fort Worth, Tex), the silicone group (SI-30NB, Allergan Medical Optics, Irvine, Calif), and the soft acrylic group (MA60BM, Alcon Surgical). The MZ60BD is a 1-piece PMMA IOL with a 6.0-mm optic. The SI-30NB has a high refractive silicone 6.0-mm optic and polypropylene loops. The MA60BM has a soft acrylic 6.0-mm optic and PMMA loops.

Informed consent was obtained before surgery from all patients participating in this study. All operations were performed by a single surgeon (K.H.). The surgical procedures used in this study have all been previously described.24 In brief, the continuous curvilinear capsulorhexis, measuring about 5.5 mm in diameter, was accomplished using a bent 25-gauge needle. After a hydrodissection, endocapsular phacoemulsification of the nucleus and cortical aspiration was performed. Next, the lens capsule was inflated with 1% hyaluronate sodium, and the IOLs were inserted into the capsular bag. Finally, using a push-and-pull hook, the surgeon carefully confirmed whether the IOLs were accurately implanted in the lens capsule.

An examination to quantitate the PCO using the Anterior Eye Segment Analysis System (EAS-1000; Nidek, Gamagori, Japan) was then performed approximately 2 years after surgery. The measurement method of the density value of PCO with the EAS-1000 system has been described in a previous study.13 In brief, the examiner first took Scheimpflug slit images of the implanted IOL at 0°, 45°, 90°, 135° meridians after full dilation. The highest quality image of each meridian was selected and then transferred to an online computer. The axial densitometry of the computer was used to calculate the scatter light density of the central 3-mm area of the posterior capsule and the IOL of the same-size area. The density value was expressed in computer-compatible tape steps (CCT). The density value in 1 section was determined by subtracting the scatter light density in the IOL from the measured value in the posterior capsule. The averaged density values of the 4 meridians were considered to be the PCO value. All measurements were performed by 3 ophthalmic technicians who were not aware of the aims of the study.

The visual acuity of these patients was determined using the decimal charts at all postoperative visits. The decline in corrected visual acuity from the best postoperative acuity at the visit either for the PCO measurement or the Nd:YAG laser capsulotomy was statistically compared between the 3 groups.

Statistical analyses were performed to compare the differences between the 3 groups using the χ² test for categorical variables and the Scheffe F test for continuous variables. Any differences at *P*<.05 were determined to be statistically significant.

### Table 1. Patient Demographics*

<table>
<thead>
<tr>
<th></th>
<th>PMMA IOL (n = 69)</th>
<th>Silicone IOL (n = 70)</th>
<th>Soft Acrylic IOL (n = 73)</th>
<th><em>P</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>67.9 ± 9.6</td>
<td>70.2 ± 8.1</td>
<td>68.4 ± 9.3</td>
<td>.29</td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>28:41</td>
<td>27:43</td>
<td>33:40</td>
<td>.71</td>
</tr>
<tr>
<td>Eye, left/right</td>
<td>38:31</td>
<td>36:34</td>
<td>32:41</td>
<td>.39</td>
</tr>
</tbody>
</table>

*PMMA indicates polymethylmethacrylate; IOL, intraocular lens.

A mean PCO value of the 3 groups was calculated. The number of eyes that underwent the PCO measurement totaled 48 in the PMMA group, 66 in the silicone group, and 71 in the soft acrylic group (Figure 1). Table 2 summarizes the mean PCO value of the 3 groups. The data are also displayed in Figure 2. The mean PCO value in the PMMA group was significantly greater than that in the silicone or soft acrylic group (*P*<.001, Scheffe test). In addition, the mean PCO value in the silicone group was smaller than that in the acrylic group, but the difference was not significant (*P* = .08).

### Table 2. Nd:YAG Laser Posterior Capsulotomy Rate and Mean PCO Value of the 3 Groups*

<table>
<thead>
<tr>
<th></th>
<th>PMMA IOL (n = 69)</th>
<th>Silicone IOL (n = 70)</th>
<th>Soft Acrylic IOL (n = 73)</th>
<th><em>P</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd:YAG laser capsulotomy rate</td>
<td>No. of eyes</td>
<td>21</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Interval, mo‡*</td>
<td>15.3 ± 5.0</td>
<td>12.2 ± 7.5</td>
<td>11.5 ± 13.6</td>
<td>.49</td>
</tr>
<tr>
<td>YAG rate, %</td>
<td>30.4</td>
<td>5.7</td>
<td>2.7</td>
<td>.&lt;.001</td>
</tr>
<tr>
<td>PCO value</td>
<td>No. of eyes</td>
<td>48</td>
<td>66</td>
<td>71</td>
</tr>
<tr>
<td>Interval, mo‡*</td>
<td>25.7 ± 2.5</td>
<td>25.6 ± 2.2</td>
<td>25.7 ± 2.8</td>
<td>.98</td>
</tr>
<tr>
<td>PMMA (CCT)</td>
<td>26.3 ± 12.2</td>
<td>12.0 ± 8.3</td>
<td>16.0 ± 10.3</td>
<td>.&lt;.001</td>
</tr>
</tbody>
</table>

*PCO indicates posterior capsule opacification; PMMA, polymethylmethacrylate; IOL, intraocular lens; CCT, computer-compatible tape steps.
‡Mean ± SD interval between cataract surgery and Nd:YAG laser capsulotomy.
*Mean ± SD interval between cataract surgery and Nd:YAG laser capsulotomy analysis system (EAS-1000) examination.

### Comment

An objective quantification method of PCO has yet to be established up to now. Although many systems using retroillumination photography have been developed, an indirect retroillumination image is unavoidably influenced...
by an uneven background illumination.\textsuperscript{25-27} In addition, these systems are considered to be unable to measure the density of capsular fibrosis and multilayered lens epithelial cells. We recently developed a new method using an axial densitometry of the Scheimpflug videophotography system to directly calculate the opacification density of the posterior capsule.\textsuperscript{15} Since the measured PCO value showed a good correlation with the patient’s visual acuity, this method is considered to be useful for the clinical evaluation of PCO.

Previous studies have shown the occurrence of PCO to differ based on the optic material of the implanted IOL.\textsuperscript{17-19,21} The low incidence of PCO in eyes with a soft acrylic IOL has recently been reported.\textsuperscript{21} On the other hand, the Nd:YAG posterior capsulotomy rates with the silicone IOL vary considerably among the published studies.\textsuperscript{28-33} Steinert and associates\textsuperscript{32} attributed the recent reduction in the Nd:YAG capsulotomy rate of the silicone IOL to improvements in the implant techniques. We also experienced a high incidence of capsular fibrosis due to the optic capture at the beginning of the silicone lens implantation.\textsuperscript{34} These results indicate that the occurrence of PCO after the silicone IOL implantation therefore substantially depends on the IOL fixation technique. This study demonstrated the density of PCO with the PMMA IOL to be much greater than that with either silicone or soft acrylic IOLs (\textit{P} < .001). In addition, the Nd:YAG capsulotomy rate

**Figure 1.** Retroillumination photographs (top) and Scheimpflug slit images (bottom) after the implantation of the 3 types of intraocular lens. A, An eye after polymethylmethacrylate lens implantation. The retroillumination photograph shows a marked proliferation of regenerated lens epithelial cells over the entire posterior capsule. In the Scheimpflug slit image, a high density of scattering light is noted along the entire posterior capsule. B, An eye after silicone lens implantation. The retroillumination photograph demonstrates a clear posterior capsule beneath the silicone optic. No areas of a high scattering light density are observed in the central posterior capsule beneath the optic in the Scheimpflug slit image. C, An eye after soft acrylic lens implantation. The retroillumination photograph shows a clear posterior capsule beneath the soft acrylic optic. The regenerated lens epithelial cells are observed to proliferate between the anterior and posterior capsules in the periphery and also migrate slightly into the retrolental space. In the Scheimpflug slit image, small areas of a high scattering light density are observed in the central posterior capsule.

**Figure 2.** Comparison of the mean ± SD posterior capsule opacification (PCO) values, measured as computer-compatible tape steps, between the 3 types of intraocular lens (IOL) groups.

**Table 3. Visual Acuity Loss From Best Postoperative Acuity on the Decimal Charts\textsuperscript{*}**

<table>
<thead>
<tr>
<th>Visual Acuity Loss</th>
<th>PMMA IOL (n = 69)</th>
<th>Silicone IOL (n = 70)</th>
<th>Soft Acrylic IOL (n = 73)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No loss</td>
<td>25 (36.2)</td>
<td>51 (72.9)</td>
<td>53 (72.6)</td>
</tr>
<tr>
<td>1 line</td>
<td>4 (5.8)</td>
<td>5 (7.1)</td>
<td>8 (11.0)</td>
</tr>
<tr>
<td>2 lines</td>
<td>13 (18.8)</td>
<td>6 (8.6)</td>
<td>3 (4.1)</td>
</tr>
<tr>
<td>3 lines</td>
<td>5 (7.2)</td>
<td>4 (5.7)</td>
<td>5 (6.8)</td>
</tr>
<tr>
<td>4 lines</td>
<td>7 (10.1)</td>
<td>1 (1.4)</td>
<td>0</td>
</tr>
<tr>
<td>5 lines</td>
<td>4 (5.8)</td>
<td>2 (2.9)</td>
<td>0</td>
</tr>
<tr>
<td>6 lines</td>
<td>6 (8.6)</td>
<td>1 (1.4)</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td>7 lines</td>
<td>3 (4.3)</td>
<td>0</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td>8 lines</td>
<td>2 (2.9)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\textsuperscript{*}PMMA indicates polymethylmethacrylate; IOL, intraocular lens. Significant differences were observed among the 3 groups (\textit{P} < .001).

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in the PMMA group was also higher than for either the silicone or soft acrylic IOL group (P<.001). On the other hand, the PCO value with silicone IOL was also smaller than that with soft acrylic IOL, but the difference was marginal. In the present series, all IOLs were placed in the capsular bag and the design of the 3 IOLs was also similar. Therefore, the greater degree of PCO with the PMMA IOL is thus attributable to the optic material itself.

Why is the extent of PCO slighter with the silicone or soft acrylic IOL than that with the PMMA IOL? In cases of complete capsular fixation, in which the lens optic edge is circumferentially covered by the anterior capsule, the extent of PCO is mainly dependent on the regenerated lens epithelial cell proliferation in the retrolental space.19,23,25 Since the acrylic optic is supposed to adhere firmly to the lens capsule,22,23 we assumed that the regenerated lens epithelial cells may thus be unable to easily invade this space.30 On the other hand, there is no reasonable explanation for the decreased PCO observed with the silicone IOL. However, its mechanism must be different from that of the soft acrylic IOL since the silicone IOL does not have as strong of an adhesive quality as that of the soft acrylic IOL.23

The visual acuity loss due to PCO was significantly greater in the PMMA group than in the silicone or soft acrylic group, while no significant difference was observed between the silicone and acrylic groups. These findings also supported the occurrence of extensive PCO in the eyes that received PMMA IOL implantation. In contrast, the eyes that underwent either silicone or soft acrylic IOL implantation maintained a substantially good visual acuity even approximately 2 years after surgery. In conclusion, this quantitative study clarified that the degree of PCO in the eyes with the PMMA IOL was considerably more extensive than that with either the silicone or soft acrylic IOL. This finding may lead surgeons to select foldable IOLs over PMMA IOLs.37,38 However, the difference between the silicone and the soft acrylic IOLs were not conclusive in this study. Furthermore, the baseline data and periodic changes of PCO could not be demonstrated in this study. As a result, a further prospective study is clearly needed to obtain a better understanding of PCO.

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REFERENCES

20. Spalton DJ. The incidence of posterior capsule opacification with PMMA, AcrySof and silicone IOLs: 3-year results. Presented at: XVth European Society of Cataract and Refractive Surgeons Congress; September 7-10, 1997; Prague, Czech Republic.