Lessons Learned: 15 Years’ Research on Posterior Capsular Opacification

Ridley Medal Lecturer reviews the state of the science on PCO.

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I began research in the field of posterior capsular opacification (PCO) 15 years ago at St. Thomas’ Hospital in London. By that time, in the 1990s, cataract surgery with IOL implantation had become the most frequently performed surgical implant procedure in the Western world, and the treatment of PCO was a major budget item for health care systems, as up to 50% of patients required Nd:YAG capsulotomy within 2 years after surgery.

To quantify PCO objectively, we developed a digital retroillumination camera at St. Thomas’ dedicated to taking pictures of the posterior capsule after cataract surgery. PCO software, based on military software, was subsequently designed to calculate the area of PCO in these images using texture-based image analysis, which was quite revolutionary at the time.1

About the same time, Alcon Laboratories, Inc. (Fort Worth, Texas) introduced the hydrophobic acrylic AcrySof IOL, and surgeons began to realize that patients implanted with this lens retained clear posterior capsules. This was a milestone for cataract surgery because it demonstrated that PCO was not an inevitable complication of the operation. To assess this phenomenon, we prospectively studied eyes implanted with three similar types of three-piece lenses made from silicone, PMMA, or the AcrySof acrylic material. We found that, 2 years postoperatively, the AcrySof IOLs had significantly less PCO than the other two IOLs.1

No one could explain this at the time, and it was not until some years later that Okihiro Nishi, MD, of Osaka, Japan, showed that this effect was largely due to the square-edged profile of the lens, which inhibits the migration of lens epithelial cells (LECs) onto the posterior capsule.2

Subsequent research has shown that a square edge around 360° of the IOL, including the optic-haptic junctions, is an important design element to minimize PCO. Another factor that influences the development of PCO is an intact capsulorhexis in complete contact with the anterior surface of the IOL. As the bag contracts and fibroses in the weeks after surgery, it compresses the IOL against the posterior capsule, producing a pressure barrier to the migration of LECs onto the central capsule behind the IOL.3 Scanning electron microscopy shows that there is significant variation in the sharpness of the edge in IOLs marketed as having a square edge, which is clinically important. Hydrophilic IOLs tend to have a blunter edge, which may explain why the IOLs are reported to get more PCO. Improved manufacturing techniques are required to give these IOLs better edges.
CURRENT RESEARCH

IOL design is one factor in the prevention of PCO, but it alone cannot eliminate the problem. Current researchers are therefore exploring other directions for PCO prevention. Four areas in particular are being investigated: (1) sequestration of LECs inside the capsular bag, (2) pharmacologic destruction of LECs, (3) physical removal of LECs, and (4) a relatively new area, devices that leave the capsular bag open.

Sequestration of LECs. The prime example of locking up the LECs in the capsular bag is the bag-in-lens concept of Marie José Tassignon, MD, PhD, FEBO. The Tassignon IOL (Morcher GmbH, Stuttgart, Germany) has a groove between its anterior and posterior haptics. The surgeon creates concentric anterior and posterior capsulorrhaces, and the lens rests with anterior and posterior leaves of the capsule in the groove. Two years later, these lenses are totally clear, with no need for posterior capsulotomy. However, postmortem eyes implanted with this lens showed marked Soemmering ring formation, although the area within the capsulorrhaces remained clear.

Pharmacologic destruction of LECs. This has been explored using the Perfect Capsule device (Milvella Pty. Ltd., Sydney, Australia). Held over the rhexis by a suction ring, the device can be used to irrigate the capsular bag with any solution of choice, isolating the bag and preventing damage to the rest of the eye. Clinical studies with this device have been disappointing. Gerd U. Auffarth, MD, of Heidelberg, Germany, and colleagues investigated the use of distilled water with the device. Two years after surgery, however, no difference in PCO was seen between control and treated eyes. In another trial in which 5-fluorouracil was used, the posterior capsule was clear, but viable LECs were still seen in the capsular bag. This lack of efficacy may be because there was insufficient exposure to the agent in the bag or more likely because the LECs were protected by residual lipophilic cortical material.

Physical removal of LECs. LEC removal can be accomplished by capsular polishing, but equatorial LECs must be removed as well as anterior LECs. If anterior capsular polishing alone is performed, an increased rate of PCO can result. We think this is because fibrosis in the capsular bag is reduced, resulting in less compression of the posterior optic edge against the capsule and a reduced barrier to migration of the LECs. A new approach to this is the Dodick laser (A.R.C. Laser GmbH, Nuremberg, Germany), which uses a laser shock wave to remove the cells.

Treatment with this laser removes LECs from the anterior capsule and the capsule fornix, and it appears to remove the adhesion molecules from the capsule as well, potentially curtailing cell migration. This is a relatively new modality, so there are a number of unknowns: Does the laser shock wave cause damage to surrounding tissues such as the iris or ciliary body, for example? Another concern is that recent laboratory work using human postmortem capsular bags grown in tissue culture suggests that if all LECs in the bag have been destroyed there will be instability and wobbling of the IOL.

Leaving the capsular bag open. The final area of recent research is with open-bag capsular devices. The dual-optic design of the Synchrony accommodating IOL (Abbott Medical Optics, Inc., Santa Ana, California) has the property of separating the anterior and posterior capsules, so that the bag can continue to respond to accommodative movement of the ciliary muscle. Surprisingly, the capsules of eyes implanted with these IOLs appear to have stayed clear after surgery. More experience is needed to see if this really is the case. If it is true, we must determine why: Is it due to a mechanical effect, a pulling taut of the capsular bag, or is there some fundamental change in the cell biology of LECs because cytokines are washed out of the bag? Whatever the case, this is an exciting area for future research.

In the past 15 years, we have come a long way in the understanding of PCO, but there is still more to be learned. I look forward to participating in this research.

TAKE-HOME MESSAGE

- IOL design is only one factor in the prevention of PCO.
- A square edge around 360° of the IOL, including the optic-haptic junctions, minimizes PCO.
- Current research includes exploring sequestration of LECs in the capsular bag, pharmacologic destruction of LECs, physical removal of LECs, and devices that leave the capsular bag open.

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