What’s about

Posterior capsule opacification
The term posterior capsule opacification is actually a misnomer. It is not the capsule which opacifies rather, an opaque membrane develops as retained cells proliferate and migrate onto the posterior capsular
History - incidence

• Secondary cataract (PCO) has been recognized since the origin of extracapsular cataract surgery (ECCE) and was noted by Sir Harold Ridley in his first IOL implantations.

• Particularly common and severe in the early days of IOL surgery (in the late 1970s and early 1980s) when the importance of cortical cleanup was less appreciated.

• 1980s and early 1990s incidence of PCO ranged between 25-50%.

• With modern techniques and IOLs, the expected rate of PCO and the subsequent Neodymium: Yttrium Aluminium Garnet (Nd: YAG) laser posterior capsulotomy rate is decreasing to less than 10%

• PCO is a major problem in paediatric cataract surgery where the incidence approaches 100%.
Aetiopathogenesis

- LECs are confined to the anterior surface at the equatorial region and the equatorial lens bow. This single row of cuboidal cells can be divided into two different biological zones
  - The anterior-central zone (corresponding to the zone of the anterior lens capsule). A monolayer of flat cuboidal, epithelial cells with minimal mitotic activity. In response to a variety of stimuli, the anterior epithelial cells ("A" cells) proliferate and undergo fibrous metaplasia. "pseudofibrous metaplasia". Late stage PCO
  - The second zone is important in the pathogenesis of "pearl" formation. Lens cells around the equator, forming the equatorial lens bow ("E" cells). Unlike within the A-cell layer, cell mitoses, division, and multiplication are quite active in this region. New lens fibres are continuously produced in this zone throughout life. Early PCO
- Although both types of cells can produce opacification, most cases of classic PCO are caused by proliferation of the equatorial cells.
Cataract surgery is the most common and well-established surgical procedure (30 Mio procedures in 2020, 4.2 Billion market).

**Important issues:**
- IOL alignment – centration (critical in premium IOLs, Accommodative and Toric)
- Posterior capsule opacification (PCO). 10 to 40% of all procedures
- Capsule fibrosis and shrink
- Post-fibrosis re-arrangement of capsular tension and loss of IOL centration
PREVENTION

• Surgical Techniques (irrigation, polishing, Nd:YAG laser photolysis)
• IOL Materials and Designs
• Pharmacological agents (cytotoxic and therapeutic agents)

PCO remains the most frequent complication!

TREATMENT

• Nd:YAG laser capsulotomy (financial burden and vision-related complications)
Why Eradicate Posterior Capsule Opacification?

1. **Nd**: YAG laser secondary posterior capsulotomy, can be associated with significant complications. Potential problems include IOL optic damage/pitting, postoperative intraocular pressure (IOP) elevation, cystoid macular oedema, retinal detachment, and IOL subluxation.

2. Dense PCO and secondary membrane formation is particularly common following paediatric IOL implantation. A delay in diagnosis can cause irreparable amblyopia.

3. PCO represents a significant cost to the health care system. In the USA, Nd:YAG laser treatments of almost one million patients per year cost up to $250 million annually.

4. A posterior capsulotomy can increase the risk of posterior segment complications in high myopes and patients with uveitis, glaucoma, and diabetic retinopathy.

5. PCO of even a mild degree can decrease near acuity through a multifocal IOL, and may interfere with the function of refractive/accommodating IOL designs.

6. A significant incidence of PCO means that cataract surgery alone may not restore lasting sight to the 25 million people worldwide who are blind from cataract.

7. Finally, a successful expansion of ECCE-IOL surgery in the developing world depends on eradication, or at least reduction of PCO, since patient follow-up is difficult and access to the Nd:YAG laser is not widely available.
Six Factors for Prevention of Posterior Capsule Opacification
Surgery-related factors to reduce PCO

• Hydrodissection-enhanced cortical cleanup:
  – The necessary tenting up of the anterior capsule during subcapsular (or cortical cleaving) hydrodissection is best achieved by using a cannula bent at the tip allowing a flow of fluid toward the capsule to efficiently separate capsule from cortex. Use of hydrodissection during cataract surgery allowed more efficient removal of cortex and LECs, (which in turn reduces PCO).
  – Surgeons use balanced salt solution while performing cortical cleaving hydrodissection. Recent experimental animal studies have shown that use of preservative-free lidocaine 1% during hydrodissection may diminish the amount of live LECs by facilitating cortical cleanup, loosening the desmosomal area of cell-cell adhesion with decreased cellular adherence, or by a direct toxic effect. Corneal endothelial toxicity continues to be a major concern of using hypo-osmolar agents (to loosen the cell-cell adhesion) during hydrodissection or any step of cataract surgery, in absence of a sealed capsular bag.
Surgery-related factors to reduce PCO

• **In-the-bag (capsular) fixation:**
  – One desired goal of in-the-bag fixation is enhancing the IOL optic barrier effect. This is maximised when the lens optic stays fully in-the-bag and is in direct contact with the posterior capsule. In case one or both haptics are not placed in the bag, a potential space is created, allowing an avenue for cells to grow posteriorly toward the visual axis.

• **Capsulorhexis edge on IOL surface**
  – A less obvious, but significant addition to precise in-the-bag fix, is creating a CCC diameter slightly smaller than that of the IOL optic. For example, if the IOL optic were 6.0 mm, the capsulorhexis diameter would ideally be slightly smaller, perhaps 5.0-5.5 mm. This places the cut anterior capsule edge on the anterior surface of the optic, providing a tight fit (analogous to a "shrink wrap") and helping to sequester the optic in the capsular bag from the surrounding aqueous humor. This mechanism may support protecting the milieu within the capsule from at least some potentially deleterious factors within the aqueous, especially some macromolecules, and some inflammatory mediators.
Three IOL-Related Factors to Reduce PCO

- A subtle difference between classic optics with a round tapered edge and optics with a square truncated edge became evident recently. A truncated, square-edged optic rim appears to cause a complete blockade of cells at the optic edge, preventing epithelial ingrowth over the posterior capsule. The enhanced barrier effect of this particular edge geometry provides another supplemental factor, in addition to the five above-mentioned factors, that has significantly diminished the overall incidence of clinical PCO.

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Three IOL-Related Factors to Reduce PCO

**IOL biocompatibility**. Lens material biocompatibility is an often-misunderstood term. It can be defined by many criteria, e.g. the ability to inhibit stimulation of epithelial cellular proliferation. The less the cell proliferation the lower the chance for secondary cataract formation.
Three IOL-Related Factors to Reduce PCO

• **Barrier Effect of the IOL Optic.** The IOL optic barrier effect plays an important role as a second line of defense against PCO, especially in cases where retained cortex and cells remain following ECCE. If accurately implanted in the capsular bag, it provides an excellent barrier effect, with almost complete filling of the capsular bag and contact of the posterior IOL optic to the posterior capsule ("no space, no cells"). A lens with one or both haptics "out-of-the-bag" has much less of a chance to produce a barrier effect. Indeed, the IOL optic's barrier function has been one of the main reasons that PC-IOLs implanted after ECCE throughout the decades did not produce an unacceptably high incidence of florid PCO.
Three IOL-Related Factors to Reduce PCO

- **Maximal IOL Optic-Posterior Capsule Contact.** Other contributing factors in reducing PCO are posterior angulation of the IOL haptic and posterior convexity of the optic. This is due to the creation of a "shrink wrap", a tight fit of the posterior capsule against the back of the IOL optic. The relative "stickiness" of the IOL optic biomaterial probably helps produce an adhesion between the capsule and IOL optic. There is preliminary evidence that the hydrophobic acrylic IOL biomaterial provides enhanced capsular adhesion, or "bioadhesion".
Pharmacological Prevention of Posterior Capsule Opacification

- intraocular application of pharmacologic agents has also been investigated by several authors as a means to prevent PCO. The idea was to selectively destroy the LECs and avoid toxic side effects on other intraocular tissues such as the sensitive corneal endothelium. Pharmacologic agents being investigated include antimetabolites (such as methotraxate, mitomycin, daunomycin, 5-FU, colchicine, and daunorubicin), anti-inflammatory substances, hypo-osmolar drugs, and immunological agents.
PCR
Peripheral Capsule Reconstructor

Pallikaris Ioannis MD, PhD

Institute of Vision & Optics
University of Crete
Greece
Advanced IOLs

• There are lenses that mimic the shape of the natural lens

• PCO may still occur (no continuous contact of the lens with the peripheral capsule)
Capsular tension rings

- Provide tension
- Do **not** prevent PCO
- Do **not** prevent fibrosis

**Capsular bending ring**
- Open, square-edge, PMMA endocapsular ring

Silicone, square-edged, closed endocapsular equator ring (E-ring)

Contraindication:
- posterior capsule disorders
- disorder of Zinn ligaments
- does not fit to any capsule size

Fits specially designed IOL

1. Long-term Study of Posterior Capsular Opacification Prevention With Endocapsular Equator Rings in Humans
   Tsutomu Hara, MD; Takeshi Hara, MD; Masaya Narita, MD; Takako Hashimoto, MD; Yuta Motoyama, MD; Takako Hara, MD

2. Preventing Posterior Capsular Opacification With an Endocapsular Equator Ring in a Young Human Eye 2-Year Follow-Up
   Tsutomu Hara, MD; Takeshi Hara, MD; Takako Hara, MD
PCR Phase A

A novel device for improved outcomes, safety, predictability and long-term stability in cataract surgery
PCR Phase A

• Retains **natural shape** of the peripheral capsule
• Prevents **PCO** (continuous contact with the peripheral capsule)
• Prevents **fibrosis**
• Prevents post-fibrosis IOL decentration/tilt
• Fits **standard** and **custom** IOLs
PCR Phase A

- Implantation is **easy and safe**, through standard port with **standard injectors**
- Provides a **stable support** for IOL implantation
- **Maintains tension** in the capsule and the zonular fibers – possibly providing a better mounting structure for accommodating IOLs
PCR Phase A

Present situation:
• Silicone* - Prototypes produced in the U.S.
• Patent Pending
• New design based on first trials

*Nusil - MED-4735
Initial trials

So far…

- 15 patients, 17 eyes with PCR implanted
- Up to three years follow-up
- No intraoperative complications
- Postoperatively, 2 patients had mild AC flare on day 1, successfully managed by steroid drops, with no residues
SLIT LAMP PHOTOS: **three-piece IOL**

*OD with PCR, 30 m*

*OS without PCR, 8m*

same patient, same IOL model
SLIT LAMP PHOTOS: one-piece IOL
SLIT LAMP PHOTOS:  WIOL

36 m  Postop

Posterior capsule tension is maintained
SLIT LAMP PHOTOS: Morcher IOL
Long term data publication

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*Since 3 November 2016
+Since July 2016
PCR phase B
Full size with capsular clips

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Simulation Study Ring-V2 of Dr Pallikaris with 2L
Phase c toric marks
Phase c custom eccentric
## Table 65: Global Forecast for the IOL Market

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Source: Market Scope
THANK YOU FOR YOUR ATTENTION