

## Commentary

# Posterior capsular opacification prevention: IOL design and material

Posterior capsular opacification (PCO) occurs in up to 50% of eyes following cataract extraction<sup>1</sup> and its treatment with Nd:YAG capsulotomy is not without complications. PCO also has important implications in the developing world,<sup>2</sup> where it may increasingly become a significant cause of treatable blindness.

Central to the pathogenesis of PCO is the concept that, following cataract surgery, lens epithelial cells (LECs) migrating from the equator of the capsular bag undergo myofibroblastic or fibroblastic-like change (so called fibrous pseudometaplasia) behind the optic of the intraocular lens (IOL) implant. In order to study the molecular biology of LECs a number of culture methods have been developed. Although many studies have been limited to LECs from animals, it has recently been possible to culture human LECs with both their capsular bag,<sup>3</sup> and in a serum free culture medium from age related cataract which closer represents in vitro conditions.<sup>4</sup> These cell culture models have been used to assess the pathophysiology of PCO and, in particular, LECs migration, proliferation, and strategies to inhibit these processes.

Anti-inflammatory drugs, cytotoxins, antimetabolites, and immunotoxins have all been employed in vitro and in vivo to destroy or suppress LECs.<sup>5</sup> Despite attempts at specifically targeting LECs—for example, by utilising monoclonal antibodies, toxic side effects remain the principal limitation in the use of such agents.

With the recognition of the role of LECs in PCO, a wide variety of techniques have also been directed at attempting to remove residual cells during surgery. These have included simple aspiration, capsule polishing, ultrasound aspiration, cryocoagulation, and osmolysis.<sup>5</sup> The fact that none of these techniques has been utilised as a routine surgical procedure reflects the difficulty in totally removing all LECs. Attempts to remove LECs may simply damage those left in situ, which may then become activated and proliferate.

The importance of the IOL as a factor affecting the incidence of PCO is well recognised.<sup>6</sup> As a result of the clinical failure of both LECs removal and pharmacological intervention to reduce PCO, emphasis has shifted towards the IOL as a practical solution. Recently, attention has been focused on the type of IOL material. Acrylic lenses, in particular the Acrysof (Alcon, Fort Worth, TX, USA), have been reported as having very low rates of PCO when compared with polymethylmethacrylate (PMMA) and silicone.<sup>7</sup> This reduced incidence of PCO has been attributed to a lower incidence of epithelial cells on the posterior capsule and their subsequent regression.<sup>8</sup>

Multiple factors affect the onset and development of PCO even in the non-pathological eye. Direct comparison between different studies, and the identification and understanding of the interrelation of these factors, has been complicated by recent changes in surgical technique and variability in defining, measuring, and assessing PCO. Slit lamp retroillumination grading of PCO and YAG capsulotomy rates are relatively subjective. However, new techniques using photographic and digital means allow precise, reproducible, quantification of PCO<sup>9</sup> and should

enable the objective assessment of different lens implants. Despite this, identifying which lens properties account for a difference in PCO rates remains difficult. This is illustrated by the studies with Acrysof lenses where lower degrees of PCO have been attributed to the acrylic material although the optic design of the implants used for comparison differed substantially.<sup>7, 8</sup>

Recent work worldwide strongly suggests that lens implant design rather than lens material may be the more important factor in the prevention of PCO. The contribution of lens design has been illustrated in the past by the varying rates of PCO between silicone lenses of a plate or loop haptic design.<sup>10</sup> In addition lenses with a plano convex optic (plano posterior) appear to have a lower rate of PCO than biconvex lenses.<sup>11</sup> It has been suggested that the lack of a mechanical or barrier effect of the IOL, which prevents LEC proliferation and central migration, explains the high incidence of regenerative PCO reported with IOL designs that hold the posterior capsule away from the lens optic to facilitate Nd:YAG capsulotomy.<sup>12</sup> Similar findings have led to the concept of “no space, no cells” as a model for the prevention of PCO by the IOL.<sup>1</sup>

In fact, Nishi (XVth Congress of the European Society of Cataract and Refractive Surgeons (ESCRS) Nice, France, September 1998) has shown that migrating LECs from the equator of the capsular bag are inhibited at a sharp discontinuous bend. Proliferation of LECs cultured in a well with a rectangular bottom ceases when a confluent cell layer is attained, due to contact inhibition. In contrast, LECs in culture do not develop contact inhibition when they meet a continuous U-shaped wall and continue to grow and climb higher. Subsequently, a PMMA IOL with sharp rectangular haptic edges was designed which produced a sharp discontinuous bend in the capsule. This was found, in an animal model, to have a lower incidence of PCO compared with an IOL with a round haptic.<sup>13</sup>

In 1995, Hara *et al* first reported on the ability of an equator ring made of silicone to prevent PCO in an animal model.<sup>14</sup> The effect of an equatorial PMMA capsular bending ring (CBR) has since been studied in a prospective randomised trial of 100 patients requiring bilateral cataract surgery.<sup>15</sup> The CBR was not polished and therefore retained its sharp rectangular edges. Each patient received a Hydroview (Storz Ophthalmics, St Louis, MO, USA) hydrogel IOL with a CBR in one eye and a Hydroview IOL without the CBR in the fellow eye. After 6 months there was significantly less PCO in the eyes with the CBR, with no constriction of the anterior capsular opening and fewer capsular folds.

The concept of contact inhibition provided by a discontinuous capsular bend also explains the significant reduction of PCO observed in patients receiving a PMMA lens implant with a sharp rectangular edged optic. In a retrospective study of 372 eyes, the incidence of PCO at 2 years was studied by comparing a sharp edged convex plano (CP) lens and a sharp edged biconvex (BC) lens with round edged BC and CP lenses.<sup>16</sup> PCO was graded after retroillumination photography and showed a significantly reduced incidence in the sharp edged lenses, irrespective of

optic convexity. A silicone IOL with a sharp optic edge has similarly shown a reduced rate of PCO, as reported by Buratto and Schmack at the ESCRS congress in 1998. Scanning electron microscopy has demonstrated that most intraocular lenses have a smooth round optic edge. In contrast, the Acrysof IOL has a sharp rectangular optic edge.<sup>17</sup> An animal study comparing Acrysof and PMMA lenses with a sharp optic edge has shown equal rates of capsular opacity,<sup>5</sup> and it remains to be seen whether other acrylic lenses with a rounded edge profile have a similar low incidence of PCO.

It appears that the sharp edge to the IOL optic alone does not prevent PCO. Factors such as the posterior convexity of the lens optic and the haptic loop angle also influence the implant-capsule interface and hence the incidence of PCO.<sup>1</sup> Several aspects of surgical technique may also be relevant. For example, the widespread use of small incision phacoemulsification surgery has seen the adoption of continuous curvilinear capsulorhexis (CCC), cortical cleaving hydrodissection, and precise "in the bag" IOL placement, all of which are recognised factors affecting the incidence of PCO. The dimensions of the CCC are particularly important and it is clear that the rhexis should overlap the optic to reduce optic-capsule capture. This phenomenon, where the optic is out, or partially out, of the capsular bag, is associated with an increase in PCO.<sup>18</sup> Not allowing the anterior and posterior capsule to fuse around the lens edge appears to facilitate migration of LECs from the anterior capsule onto the posterior capsule, and behind the lens optic where fibrosis occurs.<sup>19</sup> The finding that different lens materials show differing degrees of adhesion to the lens capsule,<sup>20</sup> illustrates a further factor which alters the lens-capsule interaction and may affect PCO rate.

A practical approach to preventing or reducing PCO is provided by exploiting the qualities of the IOL. Although the precise relation between PCO, IOL design, and material is not yet resolved, current developments highlight the importance of IOL design. Advances in cell culture and new techniques of capsule assessment should enable the objective assessment of these factors. However, at present it seems there is compelling evidence to suggest that a rectangular IOL optic edge profile is important in reducing

the incidence of PCO. This may lead to a series of changes in current lens design irrespective of the lens material.

ANDREW COOMBES  
HELEN SEWARD

Croydon Eye Unit, Mayday University Hospital,  
Thornton Heath, Surrey CR7 7YE

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