Original Article

Posterior Capsular Opacification after PMMA and Hydrophobic Acrylic Intraocular Lens Implantation

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Purpose: To compare the incidence of posterior capsular opacification after implantation of Hydrophobic Acrylic and polymethylmethacrylate (PMMA) intraocular lenses (IOLs).

Material & Methods: A retrospective chart review of all patients undergoing phacoemulsification with implantation of posterior chamber IOL by a single surgeon from February 2000 to April 2007 was done in this study. The operated eyes of the patients were divided into 2 groups. Group A eyes were implanted a PMMA IOL (LX10 BD, Alcon) while group B eyes were implanted a Hydrophobic Acrylic (Acrysof multi-piece, Alcon) IOL. A detailed analysis of the charts was done to identify all the patients in both groups who presented with decreased visual acuity due to posterior capsular opacification (PCO) more than 2 years after cataract surgery. The charts of these patients were further screened to identify those patients who had visually significant PCO (best corrected visual acuity of <6/9) requiring YAG posterior capsulotomy. Patients with any posterior capsule plaque or rupture per-op, IOL implantation in the sulcus and significant macular disease were excluded from the study.

Results: A total of 358 eyes underwent phacoemulsification with IOL implantation. There were 166 eyes in group A in which 5.5 mm PMMA IOLs (LX10 BD, Alcon) were implanted and 192 in group B eyes in which Hydrophobic Acrylic IOLs (Acrysof, Alcon) were implanted. In group A, 39.(23.4%) eyes with PMMA IOL had decreased vision due to PCO out of which only 10 patients (6%) underwent YAG posterior capsulotomy for significant visual loss. In group B, 12 (6.2%) eyes with Hydrophobic Acrylic IOL had decreased vision due to PCO out of which only 3 patients (1.5%) underwent YAG posterior capsulotomy for significant visual loss.

Conclusion: Hydrophobic Acrylic IOLs have a lower rate of posterior capsular opacification compared to PMMA IOLs.

Visually significant posterior capsular opacification (PCO), remains the most common long-term complication of modern cataract surgery[1-2]. It results in decreased visual acuity, impaired contrast sensitivity, glare and monocular diplopia.

Posterior capsular opacification (PCO) occurs in up to 50% of eyes following cataract extraction[3] and its treatment with Nd:YAG capsulotomy is not without complications. PCO also has important implications in the developing world,[4] where it may increasingly become a significant cause of treatable blindness.

Clinically, components of PCO can be different-tiated, namely a 'Regeneratory' and a 'Fibrotic' com-ponent. Regeneratory PCO occurs more frequently. It is caused by residual lens epithelial cells (LECs) from the lens equator region that migrate and proliferate in the space between the posterior capsule and the IOL. Fibrotic PCO is caused by transdifferentiated (LECs) from the anterior capsule that gain access to the posterior capsule and cause whitening and wrinkling of the capsule[2]. Both components lead to a decrease in visual function when they affect the central region around the visual axis.

Treatment of PCO by Neodymium: YAG (Nd:YAG) laser capsulotomy is effective but can lead to other complications, including an increase in intraocular pressure, ocular inflammation, cystoid macular edema, and retinal detachment. Besides, Nd:YAG laser capsulotomy does not improve visualization of the peripheral retina and increases the cost of cataract treatment. Therefore, a great deal of effort has gone into developing new ways to prevent the formation of PCO. These efforts include modification in lens design, lens material, surgical technique and other approaches. We demonstrate in our study the effects of lens design and material on PCO after uncomplicated cataract surgery.

MATERIALS AND METHODS

A retrospective chart review of all patients undergoing phacoemulsification with implantation of posterior chamber IOL by a single surgeon from February 2000 to April 2007 was done in this study. The operated eyes of the patients were divided into 2 groups. Group A eyes were implanted a PMMA IOL (LX10 BD, Alcon) while group B eyes were implanted a Hydrophobic Acrylic (Acrysof multi-piece, Alcon) IOL. A detailed analysis of the charts was done to identify all the patients in both groups who presented with decreased visual acuity due to posterior capsular opacification (PCO) more than 2 years after cataract surgery. The charts of these patients were further screened to identify those patients who had visually significant PCO (best corrected visual acuity of <6/9) requiring YAG posterior capsulotomy. Patients with any posterior capsule plaque or rupture per-op, IOL implantation in the sulcus and significant macular disease were excluded from the study.

All surgeries were performed by a single surgeon using the same surgical procedure that has been described previously. Firstly, a 2.75 mm straight scleral incision was made for IOL implantation. After incision, a continuous curvilinear capsulorrhexis, measuring approximately 5.5 mm in diameter, was accomplished using a bent needle and Utrata forceps. After hydrodissection, endocapsular phacoemulsification of the nucleus and aspiration of the residual cortex were carried out. Using a steel keratome, the wound was enlarged to 3.5 mm for acrylic and 5.5 mm for PMMA IOL implantation. The lens capsule was inflated with methylcellulose, after which the IOL was placed into the capsular bag. After insertion, the viscoelastic material was thoroughly evacuated. In this series, all surgeries were uneventful and the IOLs were accurately implanted in the capsular bag.

The patients underwent a complete ocular examination pre-operatively followed by post operative visits at 1 day, 1 week, 6 weeks and 3 months. All patients were told to report back to the clinic if there was any visual loss post operatively. Seventy five percent (n=358) patients were followed up for more than 2 years which included the patients presenting with decreased vision due to posterior capsular opacification.

RESULTS

Three hundred and fifteen eyes of 358 eyes underwent uncomplicated phacoemulsification with IOL implantation under local anesthetic. The average age was 61 years with a range of 20 to 80 years. The average age and range for group A (PMMA lens) patients was 61 years (range 30 to 86 years) and for group B (Acrylic lens) patients was 62 years (range 20 to 90 years). There were 211 females (114 in group A and 97 in group B) and 147 males (52 in group A and 95 in group B) included in the study.

There were 166 eyes in group A in which 5.5 mm PMMA IOL (LX10 BD, Alcon) was implanted and 192 in group B eyes in which Hydrophobic Acrylic IOL (Acrysof, Alcon) was implanted. In group A, 39 (23.4%) eyes with PMMA IOL had decreased vision due to PCO out of which only 10 patients (6%) underwent YAG posterior capsulotomy for significant visual loss. In group B, 12 (6.2%) eyes with Hydrophobic Acrylic IOL had decreased vision due to PCO out of which only 3 patients (1.5%) underwent YAG posterior capsulotomy for significant visual loss.

PCO developed in 51 patients out of which 39 patients were in group A (PMMA lens) and 12 patients in group B (Acrylic lens). In group A patients 35 eyes developed Elschnig pearls and only 4 developed posterior capsular fibrosis. In group B patients 11 eyes developed Elschnig pearls and one patient had posterior capsular fibrosis showing a much higher rate of Elschnig pearls in both groups.

DISCUSSION

In view of the large amount of cataract surgery being performed, posterior capsular opacification has important medical, social, and economic implications, and consequently, there is considerable interest in its prevention. Capsular opacification stems from the continued viability of lens epithelial cells (LECs) remaining after removal of the nucleus and cortex. It may result in adherence of the anterior capsule to posterior capsule creating a closed space consisting of nucleated bladder cells (Wedl cells) resulting in Soemmerring's ring or migration of epithelial cells across the anterior or posterior capsule, that may cause capsular wrinkling and opacification. LECs are capable of undergoing metaplasia with conversion to myofibroblasts. A matrix of fibrous and basement membrane collagen can be produced by these cells, contraction of which will cause wrinkles in the posterior capsule with resultant distortion of vision and glare. All of these processes are influenced by cytokines (interleukins I and 6), growth factors (transforming growth factor β, fibroblast growth factor, epithelial growth factor), and extracellular matrix proteins[5].

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 meticulous hydrodissection, complete cortical aspiration, polishing of the anterior and posterior capsules, ultrasound aspiration, cryocoagulation, and osmolysis[6]. The fact that none of these techniques has been utilized 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.[7] 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 have been reported as having very low rates of PCO when compared with polymethylmethacrylate (PMMA) and silicone[8]. This reduced incidence of PCO has been attributed to a lower incidence of epithelial cells on the posterior capsule and their subsequent regression[9].

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[10]. In addition lenses with a plano convex optic (plano posterior) appear to have a lower rate of PCO than biconvex lenses[11].11 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 regeneratory PCO reported with IOL designs that hold the posterior capsule away from the lens optic to facilitate Nd:YAG capsulotomy[12]. Similar findings have led to the concept of "no space, no cells" as a model for the prevention of PCO by the IOL[3]. 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[13]. The sharp optic edge creates higher pressures on the posterior capsule and acts as a mechanical barrier to lens epithelial cell migration, whereas the rounded optic edge does not concentrate pressure in this manner and permits easy migration of these cells. Polyacrylic lenses have a more defined and squarer edge profile, and this may be important in the lower rates of PCO seen with this lens.

A recent systematic review based on Cochrane methodology included 26 prospective randomized controlled trials with a follow-up of at least 12 months and showed that in 5 of 7 studies, visual acuity was better in sharp-edged IOLs than in round-edged IOL. The PCO score was significantly lower with sharp-edged IOLs but did not differ significantly between 1-piece and 3-piece open-loop IOLs[14].

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[15]. 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[16].

Despite all advantages, sharp-edged IOLs can also cause problems. In some cases after implantation of lenses with sharp posterior and anterior optic edges, an increased incidence of persistent edge-glare phenomena has been reported. Intraocular lenses with a rectangular- edge cause the light rays that are refracted through the peripheral IOL to be more intense on the peripheral retina. Round-edged IOLs disperse the rays of light over a larger surface area of the retina, leading to decreased glare.

Several aspects of surgical technique may also be relevant in reducing the incidence of PCO. 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[17]. 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[18]. The finding that different lens materials show differing degrees of adhesion to the lens capsule[19], illustrates a further factor which alters the lens-capsule interaction and may affect PCO rate.

Our study quantitatively demonstrates that the degree of PCO in the eyes with a PMMA IOL is more extensive than that in the eyes with a hydrophobic acrylic IOL. Specifically, PCO in the presence of a PMMA IOL increased from the early postoperative period, but the increase virtually reached a peak by12 months after surgery. Furthermore, the Nd:YAG capsulotomy rate was also worse with the PMMA IOL than with the acrylic IOL. At one month after surgery, the best corrected visual acuity was the same between eyes with the PMMA and those with the acrylic IOL. Thereafter, however, visual acuity in eyes with the PMMA IOL worsened significantly with time, so that the visual acuity in eyes with a PMMA IOL was worse than that in eyes with an acrylic IOL in the later postoperative period. Thus, our results clearly show that PCO in the presence of a PMMA IOL impairs visual acuity more so than does that in the presence of an acrylic IOL. The clearer posterior capsules with polyacrylic lenses are reflected in the significantly lower PCO rates for this group (6.2% compared to 23.4% for PMMA).

Treatment of PCO by neodymium: YAG (Nd:YAG) laser capsulotomy is effective but can lead to other complications, including an increase in intraocular pressure, ocular inflammation, cystoid macular edema, and retinal detachment. Besides, Nd:YAG laser capsulotomy does not improve visualization of the peripheral retina and increases the cost of cataract treatment. Therefore, a great deal of effort has gone into developing new ways to prevent the formation of PCO. These efforts include modifications in lens design, lens material, surgical technique, and other approaches.

On slit lamp examination, the pattern of PCO with the PMMA IOL is different from that with the other types of IOL. It is known that capsular fibrosis due to proliferation of fibroblast-like LECs is predominant in the early postoperative period. With the PMMA IOL, flat spindle shaped LECs invade the retrolental space from the early period. Because these cells are well demarcated and not accompanied by fibrosis, they are considered to be lens fiber cells that might have originated at the lens equator. In general, the fiber cells grow and subsequently develop into Elschnig pearls.

However, with the PMMA IOL, swelling of the lens fiber cells is not so marked as to form a thick layer even during two year follow up. Thus, early invasion of a flat layer of lens fiber cells is characteristic of PCO after PMMA IOL implantation. As the proliferation pattern of LECs may not be influenced by the IOL design, this distinct pattern of PCO may be caused by the PMMA optic material.

Hollick et[20] al studied the visual outcome, neodymium:YAG (Nd:YAG) capsulotomy rates, and percentage of posterior capsular opacification (PCO) seen with polymethylmethacrylate (PMMA), silicone, and polyacrylic intraocular lens implants 3 years after extracapsular cataract surgery with capsulorhexis. Ninety eyes of 81 patients were examined at a British teaching hospital. They found that intraocular lenses made from polyacrylic are associated with a significantly reduced degree of PCO and lower YAG rates. There was a significant difference in percentage PCO at 3 years among the lens types (*P* 5 0.0001). Polyacrylic lenses were associated with less PCO (10%) than silicone (40%) and PMMA lenses (56%). The YAG capsulotomy rate was 0% for polyacrylic, 14% for silicone, and 26% for PMMA (*P* 5 0.05).

Hayashi et al[21] found that the degree of posterior capsular opacification was significantly less in the hydrophobic acrylic IOL (AcrySof, MA60BM, Alcon Surgical, Fort Worth, TX, USA) compared to a hydrogel IOL (Hydroview, H60M). Of the 100 eyes in each group, two (2%) in the acrylic group and 28 (28%) in the hydrogel group required Nd:YAG capsulotomy within 24 months after surgery. Vock et[22] al showed that the incidence of Nd:YAG capsulotomy in patients with 3 piece hydrophobic Acrylic IOL with sharp optic edges over 10 years was 42% (n=99) compared to 18% (n=44) in 3 piece silicone IOL with round optic edges. Ten years after surgery, acrylic IOLs seemed to lose their PCO preventive effect, despite their sharp optic edges.

In conclusion, the extent of PCO after PMMA IOL implantation is substantially greater than that after hydrophobic acrylic IOL implantation. The rate of Nd:YAG capsulotomy was also higher with the PMMA IOL than with the acrylic IOL, reflecting the fact that deterioration of visual acuity due to PCO was more pronounced in eyes with a PMMA IOL. The results of previous and current studies suggest that PMMA material may allow active proliferation of LECs, possibly because of its hydrophilicity, and therefore may not be appropriate for use as an optic material.

By reviewing past literature it is clear that PCO rate is significantly higher with PMMA IOL than the Acrylic IOL, as is clearly shown by the following table.

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