·Clinical Research·

Risk factors for anterior chamber membrane formation after phacoemulsification

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Abstract

• AIM: To investigate the risk factors for the development of membrane formation in the anterior chamber after phacoemulsification.

• METHODS: A total of 1 356 patients who underwent phacoemulsification with implantation of single piece polymethyl methacrylate (PMMA) IOL were prospectively evaluated. Presence of pseudoexfoliation syndrome, nuclear hardness, pupil size, phaco time, effective phaco time, systemic diseases, postoperative complications (capsulorhexis rupture, zonular dialysis, posterior capsule rupture with vitreous loss), location of IOL placement and postoperative complications(intraocular pressure changes, synechia formation) were analyzed as risk factors for development of membrane formation.

• RESULTS: In 111 (8.1%) patients postoperative fibrinous anterior uveitis with membrane formation was observed. The mean time for membrane formation was postoperative second day (range postoperative 1st and 7th day). Mean duration of the presence of membrane was 5.2 days (range 1 to 48 days). Among the patients who had membrane formation, +4 hardness of the nucleus was present in 45%, while it was present in only 13.5% of patients who did not have membrane formation. The difference was statistically significant (P <0.05). In the membrane-forming group, mean phaco time was 2.4 minutes and mean effective phaco time was 32.8 seconds, compared to 1.8 minutes and 22.1 seconds in the membrane-free group. Both parameters were significantly longer in the membrane-forming group (P<0.05). Posterior capsule rupture with vitreous loss and sulcus implantation of IOL was seen in 33% of membrane-forming patients and in 11% of membrane-free patients (P<0.05). Other risk factors were not statistically different between membrane-forming and membrane-free patients. On postoperative first and 7th day, the mean best corrected visual acuity in the membrane-forming group was 0.2 and 0.4 respectively, versus 0.4 and 0.6 in the membrane-free group on Snellen chard (P<0.05). But three months after surgery, the best corrected visual acuity was similar between the membrane-forming and membrane- free patients (0.8 and 0.9 respectively).

• CONCLUSION: Higher nucleus hardness, longer phaco time and effective phaco time, and posterior capsule rupture during surgery are risk factors which significantly associated with postoperative fibrinous membrane formation in the anterior chamber.

• KEYWORDS: nucleus hardness; phaco time; effective phaco time; posterior capsule rupture; membrane formation; fibrin reaction

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INTRODUCTION

Phacoemulsification with continuous curvilinear capsulorhexis (CCC) and in-the-bag implantation of intraocular lenses(IOLs) has some advantages, including low postoperative astigmatism, good wound stability, and better visual rehabilitation [1,2]. In addition, the reduced postoperative inflammatory response which has been attributed to a reduced disruption of the blood-aqueous barrier (BAB) via a marked reduction in incision size and invasiveness was also a major advantage[1-3].

The surgical inflammatory response results from various factors, such as surgical trauma, immune reaction to implanted materials such as the IOL, previous inflammatory disease, presence of glaucoma, degree of iris destruction, and history of systemic diseases like diabetes mellitus [1-3]. Severe inflammatory reaction may lead to dense pupillary fibrin membrane formation that can in turn cause patient discomfort, delayed recovery and suboptimal visual results[4,5].

In this study, we evaluated risk factors and postoperative outcomes in patients who had sterile pupillary dense membrane formation.

MATERIALS AND METHODS

A total of 1 356 patients who underwent phacoemulsification with PMMA IOL implantations in posterior chamber were prospectively evaluated in this study. The followings were examined as risk factors for anterior chamber

membrane formation: systemic diseases, pseudoexfoliation syndrome (PEX), uveitis, pupil size, nuclear hardness, phaco time, effective phaco time, perioperative complications (capsulorhexis rupture, zonular dialysis, posterior capsule rupture (PCR) with or without vitreous loss), location of IOL placement and postoperative complications (intraocular pressure changes, synechia formation).

Of these patients, 111 (8.1%) had severe fibrinous anterior uveitis that caused pupillary membrane formation in the postoperative period. For statistical comparison, a group of 111 patients who did not have membrane formation but who were similar in age and gender to the membrane forming-patients were randomly selected from of the pool of study patients (1356-111).

All patients were examined preoperatively by three authors as follows. Best corrected visual acuity was evaluated with a Snellen chart. Intraocular pressures were measured by application tonometry. Slit lamp biomicroscopy examination was performed on all patients. Presence of PEX, type of cataract, nuclear hardness, iris color, pupil size after pharmacological dilatation and presence of phacodonesis were evaluated.

Nuclear hardness was evaluated clinically according to the color of the nucleus and fundus reflex [6]. Nuclear hardness grading criteria are given in Table 1. Systemic diseases such as hypertension, diabetes mellitus and connective tissue diseases were also assessed.

All eyes received topical antiprostaglandin and cyclopentolate agents before surgery under local or general anesthesia. Phacoemulsification was performed by the same two surgeons, who were experienced in both techniques, with the Series 20000 Legacy phacoemulsification unit (Alcon Laboratories). After a clear corneal incision with 3.0mm knife, anterior chamber was filled with a dispersive viscosurgical device (Viscoat Sodium chondroitin sulfate 4.0% & sodium hyaluronate 3.0%) than continuous curvilinear capsulorhexis (CCC) was created. Trypan blue capsular dye was used during CCC for white mature or hypermature cataracts. After bimanual divide-and-conquer phacoemulsification in the capsular bag, the cortical lens material was removed via bimanual irrigation and aspiration. The bag was filled with a cohesive viscosurgical device (Healon, 1% Sodium Hyaluronate) and incision side was enlarged with 5.0 knife, intraocular lens (Alcon Crystal 5T PMMA single-piece IOL, round optic edge of 5mm and total length of 12.5mm) was inserted in the bag. The incision side was close with one suture. Precise irrigation and aspiration was performed to remove viscosurgical device from both anterior chamber and from capsular bag. Subconjunctival antibiotic and steroid injection was performed in all patients.

Table 1 Grading criteria for nuclear hardness[9]

Grade	Color	Red reflex
1	Transparent or pale gray	High
2	Gray or gray-yellow	Marked
3	Yellow or yellow-gray	Good
4	Yellow-amber or amber	Poor
5	Dark brown or black	Absent

If PCR occurred and vitreus prolapsed to anterior chamber, anterior vitrectomy was performed. Posterior chamber, behind the iris was filled with same cohesive viscosurgical device, a single-piece PMMA IOL with 6mm optic and total length of 13.5mm was inserted into the sulcus.

Intraoperative parameters phaco time (minute), mean phaco power (average power) (%), and effective phaco time were recorded. The effective phaco time was calculated with the following formula: phaco time (seconds) X mean phaco power (average power)/100.

Postoperative treatment was standardized for all patients and was comprised of topical steroids four times a day for four weeks, antibiotic drops four times a day for one week and tropicamide or cyclopentolate once each night for one week.

As a rule, patients were examined 1 day, 1 week, 1 month and 3 months after surgery by same three authors. At each follow-up visit, BCVA and IOP were measured. Slit lamp examination was performed , to examined completeness of removal of cortical material, pupillary dilatation was done, pigment deposits on the IOL or on corneal endothelium, or the presence of cells in the anterior chamber, were also recorded. Fibrinous anterior uveitis severe enough to develop membrane formation was determined by examination with a biomicroscope, and was defined as obstruction of the clear visibility of the IOL as seen through the microscope.

If present, fibrinoid membranes anterior to the IOL, cystoid macular edema or vitreous changes were also recorded. To exclude patients who had postoperative endophthalmitis purulent secretion, conjunctival hyperemia, pain, hypopion were evaluated.

The results were analyzed using statistical analysis software (SPSS for Windows, Release 10.07J-1/June/2000).

RESULTS

Of 1 356 patients who underwent phacoemulsification with PMMA IOL implantation, 111 patients (8.1%) developed fibrinoid membranes in the anterior chamber. No patients had uveitis before surgery.

The mean age of patients in the membrane-forming group was 67 years (range 3 to 98 years) and was not significantly different from that of the control group (the mean was 68 years, range 44 to 88 years). The membrane-forming group had 69 women and 42 men, and the control group had 59

women and 52 men. Diabetes mellitus was present in 16 patients (14.4%) in the membrane-forming group and in 15 patients (13.5%) in the control group. Systemic hypertension was observed in 38 patients (34.2%) in the membrane-forming group and 42 (37.8%) in control patients the differences were not significant for both parameters (P>0.05 for each). No one had systemic connective tissue disease and no one used systemic steroids and/or immune suppressive medication for other reasons.

Mean preoperative IOP was 14.1mmHg (range to 8-22 mmHg) in the membrane-forming group and 14.7 mmHg (range to 10-22mmHg) in the control group. This difference was not significant (P>0.05).

The earliest membrane formation was seen on the postoperative 1, and the latest began on the postoperative 7th day (mean=postoperative 2nd). The earliest membrane disappearance occurred on postoperative 2nd day and the latest on 48th day. The mean duration of the membrane in the anterior chamber was 5.2 days.

The mean preoperative BCVAes were similar in both groups, it was 0.1 in the membrane-forming group (light perception to 0.6) and 0.2 in the control group (finger counting from 50cm to 0.6) (P>0.05). The mean postoperative BCVA was lower in the membrane-forming group on postoperative 1st day (mean 0.2, finger counting from 2 meter to 0.8) than that in the control group (mean 0.4, range 0.05 to 1.0). BCVA remained lower at one week after surgery that the mean BCVA 0.4 (range 0.05 to 0.8) in membrane-forming group and it was 0.6 (range 0.2 to 1.0) in control group, at one month and at 3 months after surgery the mean BCVA of 0.8 (range 0.4 to 1.0) in membrane-forming group was similar to control group of 0.9 (range 0.7 to 1.0).

Types of cataract in the membrane-forming group were given in Table 2 and nucleus hardness was given in Table 3. Nucleus hardness and the presence of mature or hypermature cataracts were significantly higher in the membrane-forming group (P<0.05). All patients had brown iris color in both groups.

PEX in the membrane-forming group was seen in 18 eyes (16.2%) and in the control group in 12 eyes (10.8%), but this difference was not significant (P>0.05). A pupil size of less than 5mm during surgery was seen in 3 eyes in the membrane-forming group, that iris retractor hocks were placed in two of them and pupil stretching was done in one eye. No eyes had less than 5mm pupil size in the control group, but the difference of pupil size between the groups was not significant (P>0.05).

Capsulorhexis rupture was observed in 15 eyes (13%) in the membrane-forming group and in 12 eyes (10%) in the control group.

Table 2 Types of cataract

Groups	A	B	C	D
M	43.2%	32.4%	24.3%	0.1%
N	6.3%	57.6%	36%	0.1%

M: Membrane-forming Group; N: Control Group; A: Mature or Hypermature cataract; B: Nuclear sclerotic; C: Cortical or subcapsular; D: Other

Table 3 Nucleus hardness

Groups	+4	+3	+2	+1
M	45%	18%	32.4%	4.5%
N	13.5%	25.2%	46.8%	14.4%

M:Membrane-forming Group; N: Control Group

Zonular dialysis occurred in 2 eyes (1.8%) in the membrane-forming group and in 1 eye (0.9%) in the control group, these differences were not significant (P>0.05 per each).

Mean phaco time was 2.4 minutes (±1.8) in the membrane-forming group and 1.8 minutes (±1.1) in the control group. Mean effective phaco time was 32.8 (±26.6) seconds in the membrane-forming group and 22.1(±16.9) seconds in the control group. Both of these parameters were statistically longer in membrane-forming group (P<0.05).

PCR and vitreous loss was observed in 37 eyes (33%) in the membrane-forming group and in 13 eyes (11%) in the control group. This difference was statistically significant(P< 0.05). In eyes with PCR and vitreous loss, sulcus implantation of the IOL was done after performing anterior vitrectomy. There fore sulcus implanted IOL were significantly higher in membrane-forming group than that of control group.

A postoperative IOP higher than 22mmHg was observed in 7 eyes in the membrane-forming group on postoperative 1st day and this number decreased to 3 eyes in the first postoperative week. Postoperative IOPs in the control group were less than 22mmHg at all time during following period. At one month and three months after surgery, the IOPs in the membrane-forming group had returned to normal level and were similar to those in the control group.

Posterior synechias developed in 3 eyes in the membrane-forming group, but no one in the control group.

For treatment in the membrane-forming group, postoperative subconjunctival steroid injections and/or systemic steroids in addition to topical steroid eye drops were given according to the severity of membrane formation.

DISCUSSION

Postoperative membrane formation is the combined result of a reaction to surgical trauma and an immune response to the IOL as a foreign body. The evolution of modern cataract extraction including a CCC, in-the-bag phacoemulsification

and lens implantation has resulted in decreased postoperative inflammation via reduced disruption of the blood-aqueous barrier (BAB)[1,7-9]. The immune response is also reduced by postoperative treatment with antiprostaglandin agents such as steroidal and non-steroidal eye drops[7,9-11].

Even after these improvements severe anterior uveitis result of fibrin membrane formation is still seen in some patients. In our study, 8.1% of all patients who underwent phacoemulsification and PMMA IOL implantation developed fibrin membranes in the anterior chamber postoperatively. This compares to the incidence of 6.5% that Geerards and Logerhorst [4] reported for fibrin reaction. Miyake *et al* [5] reported an incidence of 4.4% for fibrin reaction in eyes that underwent either extracapsular cataract extraction (ECCE) or phacoemulsification. In both of these studies, the incidence was stilly lower than our result.

In the literature, the time of appearance of the membrane varies between postoperative day 1 and a few weeks later. In the study by Geerards and Longerhorst [4] the earliest membrane was seen on postoperative 2nd day and the latest 15 days after operation. The peak time of occurrence was at the end of the first postoperative week. In our study, the times were little earlier that the earliest membrane was seen on postoperative 1st day and the latest appeared on 7th day with the mean being postoperative 2nd day.

Postoperative membrane formation is mainly the result of trauma, but various other factors appear to be involved. For example, ultrasonic trauma may be an important cause of BAB disruption [7]. In our study both phaco times and effective phaco times were significantly higher in membrane forming group than control patients that supports the ultrasonic trauma as a risk factor of membrane formation. It has been reported that in-the-bag fixation with intact CCC is less disruptive to the BAB as it causes less zonular stress and enables more stable IOL fixation and more precise centration, and consequently isolates the IOL from contact with the posterior uveal surface which could initiate inflammation[1,12,13]. Chee *et al* [1] evaluated BAB breakdown by using a flare meter and found that flare had returned to preoperative levels by one month after surgery in dark brown eyes. In the study by Siriwarde *et al* [12], flare after phacoemulsification returned to baseline levels by 6 months in eyes without PEX or other eye disease. However, Kruger *et al* [7] reported that restoration of the BAB was not complete at one year after surgery. We did not measure flare in the anterior chamber. We evaluated inflammation that was severe enough to create a dense membrane. The latest of these membranes had disappeared by postoperative day 48 as revealed by slit lamp, but the BAB breakdown would be seen as much more prolonged if analyzed with a flare meter.

Ponde and coworkers[13] reported in two different studies that intact CCCs stimulate a weaker inflammatory response than those that are not intact. In intact CCCs, the IOLs can adhere to the anterior and posterior capsule, resulting in the encapsulation of the lens epithelial cells Residual lens epithelial cells are known to produce several chemical factors including prostaglandins, interleukins, and basic fibroblast growth factors [11,14]. In agreement with other reports, we observed that fibrin membrane formation was greater in eyes with a torn CCC margin and subsequent sulcus implantation.

Complications that increase surgical trauma such as PCR and vitreous loss were significantly more frequent among our patients who formed membranes. Vitreous loss it self and anterior vitrectomy with its prolonged operation time both increase surgical trauma and it also causes sulcus implantation rather than in the bag implantation.

Increased vascular permeability due to systemic diseases such as diabetes mellitus, hypertension and connective tissue disorders, or ophthalmic pathologies such as anterior uveitis and PEX, have been implicated in BAB disruption and subsequent heavy leakage of protein and fibrinoid substance from the iris vessels causing fibrinoid membrane formation in the anterior chamber [4,9]. Miyake *et al* [5] found that the incidence of fibrin reaction in patients with diabetes mellitus (51%) was not significantly different from that in non-diabetic patients (44%). However, the incidence in patients with systemic hypertension (6.7%) was significantly higher than that in patients without systemic hypertension (3.8%). We found no difference in membrane formation in terms of systemic diseases such as diabetes mellitus and hypertension.

The incidence of PEX in eyes varies across ethnic groups and is seen frequently in Scandinavian people who have blue or light brown irises. PEX is also seen as frequently as Scandinavian people in our population who have heavy pigmented iris in-contrast to Scandinavian people. Even A strong correlation between preoperative PEX and postoperative fibrinoid reaction has been reported [14]. It was not supported statistically by Dosso and coworkers [15] observation. We also did not observed PEX, as a major risk factor for fibrin membrane formation.

It has been suggested that a tendency toward postoperative eye inflammation is directly proportional to the degree of iris pigmentation[1,5,16-18]. Our study population was comprised mainly of patients with dark, heavily pigmented irises. The presence of both PEX and heavy iris pigmentation may have increased the risk for fibrin membrane formation in our patients.

In combination with PEX and heavy pigmentation of the iris, may decreased pupillary dilatation, increased in surgical trauma, complications and BAB disruption that main. Phaco

time and phaco power increased according to increased nucleus hardness which are seen in mainly mature and hypermature cataracts which we observed in our cases.

Most of our patients had personal risk factors. PEX and iris pigmentation are related to ethnic origins and are not changeable factors, but surgery that can be performed earlier before that cataracts become mature or hypermature may help to minimize surgical trauma.

Modern cataract surgery that includes CCC and the use of Trypan blue as a capsular dye for white cataracts, combined with the use of new-generation, high-quality machines that are more effective for hard nuclei and in-the-bag phacoemulsification and IOL implantation can help to minimize surgical trauma. All of our patients underwent cataract extraction with same technique by same two high level experienced surgeon and all materials such as both viscoelastic substances and IOL's were the same. Therefore all patients underwent operation in same surgical condition.

In summary, we found that fibrin membranes occurred more frequently in eyes which had hard nuclei therefore underwent both longer phaco times and effective phaco times and also had higher risk factors for complications such as CCC torn, PCR, vitreus loss, as a result having excessive trauma and longer surgical times.

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