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The impact of capsulorhexis diameter, localization and shape on posterior capsule opacification

Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Data Interpretation
- E** Manuscript Preparation
- F** Literature Search
- G** Funds Collection

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Background:

The aim of this study was to evaluate the impact of capsulorhexis diameter, localization and shape on posterior capsule opacification (PCO) development after cataract extraction with phacoemulsification.

Material/Methods:

We retrospectively analyzed of 297 patients who underwent phacoemulsification and AcrySof SA60AT implantation.

In a first group of 97 patients, 53 received small capsulorhexis (3.9 to 4.9 mm in diameter) and 44 patients received large capsulorhexis (5.0 to 5.9 mm in diameter). Another group of 99 patients was split into subgroups – 66 patients whose capsulorhexis were centrally located and 33 patients whose capsulorhexis were paracentral. A third group of 101 patients was split into subgroups – a subgroup of 59 patients were classified as having a regularly rimmed capsulorhexis and a subgroup of 42 patients as having an irregularly rimmed capsulorhexis. At 6 months follow-up, PCO was classified as none, mild, moderate, or severe, depending on the number of quadrants involved.

Results:

86.79% of the patients with a small capsulorhexis had no or mild PCO ($p < 0.001$), whereas, 68.18% of the patients with a large capsulorhexis experienced moderate or severe PCO; 89.4% of the patients with a central capsulorhexis had no or mild PCO ($p < 0.001$), whereas, 75.75% of the patients with a paracentral capsulorhexis had moderate or severe PCO; 86.44% of the patients with a regularly rimmed anterior capsulorhexis had no or mild PCO ($p < 0.001$); and 69.04% of the patients with an irregular capsulorhexis rim had moderate or severe PCO.

Conclusions:

A small capsulorhexis diameter, its central localization and regular shape result in less PCO following phacoemulsification.

Key words:

posterior capsular opacification • PCO • anterior capsulorhexis • capsulorhexis diameter • capsulorhexis localization • capsulorhexis shape • AcrySof • phacoemulsification

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BACKGROUND

Posterior capsular opacification (PCO) is the most common long-term complication following modern cataract surgery. It usually causes a decrease in visual acuity by directly blocking the visual axis. Clinically, visual symptoms may vary widely in proportion to the amount of PCO [1]. It occurs in between <5% and 50% of uncomplicated senile cataracts during the first 2 years following cataract surgery [2–4].

PCO develops over a clear posterior capsule from a few months to a few years after uncomplicated cataract surgery. Regenerative PCO is caused by residual equatorial lens epithelial cells (LEC) proliferation and migration from the equatorial region of the lens capsule to the posterior capsule surface. In regions of the anterior and posterior capsule junction, Elschnig pearls can form, located behind the iris or filling the pupil space. The formation of Elschnig pearls causes a decrease in visual acuity and sometimes double vision following the implantation of an intraocular lens (IOL).

Capsular fibrosis is less common and usually appears earlier than Elschnig pearls; it is thought to be caused by LEC metaplasia with myofibroblast development. Clinically, it is seen as a wrinkling on the posterior capsule, haziness and grey-white streaks and plaques on the surface of the posterior capsule. Symptoms reported by patients include image distortion, glare and visual acuity reduction [4,5].

Risk factors

Several systemic and ocular associations have been cited as influencing the development of PCO. The incidence of PCO is more common in young patients and those with uveitis, pseudoexfoliation syndrome or traumatic cataracts. Myopic eyes have been postulated to increase the risk of PCO; this probably occurs because IOL implantation was deferred in them, but a study of IOL implantation in myopic eyes showed no association between the degree of myopia and the degree of PCO [4,6,7]. When compared with non-diabetic patients, diabetic patients had significantly more PCO following cataract surgery, but the stage of diabetic retinopathy and the systemic status of the diabetes does not seem to correlate with the degree of PCO [8]. Patients with retinitis pigmentosa showed a significantly higher incidence and density of PCO [9]. Patients with myotonic dystrophy required multiple capsulotomies following cataract surgery due to PCO and progressive capsulorhexis contracture [10].

Other factors that influence PCO development are: the intraocular lens type (material, design, optic size and edge, haptic design), accurate hydrodissection and removal of cortical masses, anterior capsule polishing, in-the-bag fixation of the optic and the haptic IOL part and anterior capsulorhexis localization and diameter. Numerous studies have examined the influence of physical properties of the IOL and accurate surgical lens removal technique on the formation of the PCO [11–19]. Relatively few studies have investigated the influence of anterior capsulorhexis on the development of posterior capsule opacification [20–22].

The present study evaluates the impact of anterior capsulorhexis diameter, localization and shape on PCO development following cataract extraction with phacoemulsification.

MATERIAL AND METHODS

This retrospective analysis reviewed 297 patients above age 45, randomly chosen from a group of 3500 operated patients who had undergone phacoemulsification and IOL implantation in the capsular bag at the Department of Ophthalmology, Medical University of Warsaw from September 2007 to September 2008. Inclusion criteria were used to define the presence of a senile cataract in an otherwise normal eye. Exclusion criteria consisted of: previous eye surgery and ocular or systemic diseases (eg, diabetes mellitus, rheumatoid diseases and serious cardiovascular diseases). Visual acuity, intraocular pressure (IOP), slit lamp examination, fundus examination, B-scan ultrasonography, keratometry, IOL power calculation with a biometry measurement and systemic examinations were all evaluated prior to surgery in all patients. All patients used 0.1% diclofenac sodium solution eye drops (Naclof; Novartis) 3 times on the day before surgery and on the day of surgery.

Surgical technique and medication were standardized. Phacoemulsification was performed by a single surgeon (E.L.-W.) under topical anesthesia. In the first group of 97 patients, 53 patients (55%) were postoperatively assigned to the group whose capsulorhexis were classified as small (3.9 to 4.9 mm in diameter) and 44 patients (45%) were assigned to the group whose capsulorhexis were classified as large (5.0 to 5.9 mm in diameter). The capsulorhexis were centrally located and regularly rimmed. Another group of 99 patients was postoperatively assigned into 1 of 2 subgroups – the first subgroup of 66 patients (66%) had capsulorhexis that were classified as centrally located and the second group consisted of 33 patients (34%) whose capsulorhexis were classified as paracentral. The capsulorhexis were defined as centrally located when the center of the capsulorhexis was in the center of the patient's own lens and later in the center of the implanted posterior chamber intraocular lens (PCIOL). The capsulorhexis were defined as paracentral when the center of the capsulorhexis was not in the center of the patient's own lens and the PCIOL. Capsulorhexis shift was at least 1.5 mm, which is half the radius of the optical part of implanted PCIOL. The capsulorhexis were small (3.9 to 4.9 mm in diameter) and regularly rimmed. A third group of 101 patients was also postoperatively assigned into 1 of 2 subgroups depending on the shape of their capsulorhexis rim. The first subgroup of 59 patients (58%) was classified as having a regularly rimmed capsulorhexis and the second subgroup of 42 patients (42%) was classified as having an irregularly rimmed capsulorhexis. The capsulorhexis were defined as regularly rimmed when the edge was smooth and the main perpendicular diameters were similar in length. The capsulorhexis were defined as irregularly rimmed when the edge was uneven at least on 1/3 of the capsulorhexis rim or the main perpendicular diameters were not similar in length. The capsulorhexis were small (3.9 to 4.9 mm in diameter) and centrally located.

The edge of the capsulorhexis had to lie completely on the intraocular lens optic for 360 degrees, even if it was eccentric, in all groups.

A 6.0-mm diameter optic, single-piece, hydrophobic acrylic intraocular lens (Alcon, model SA60AT) was implanted. Postoperatively, all patients used neomycin, polymyxin, and

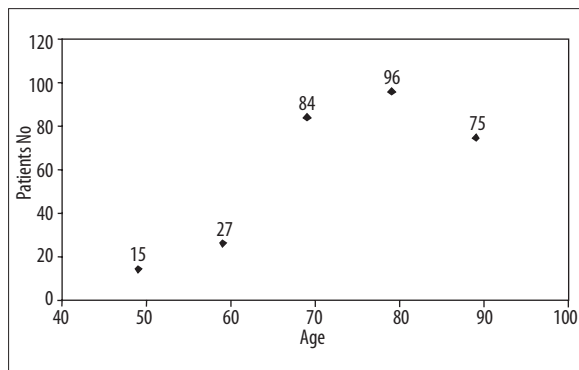


Figure 1. Patients demographics (N=297).

0.1% dexamethasone solution eye drops (Maxitrol; Alcon Pharmaceuticals) 4 times a day for 1 month. Postoperative follow-up visits were performed on days 1, 3, 14, 30, 90, and 180. Patients were examined and refracted, and visual acuity was assessed using the Snellen chart. Digital retroillumination imaging of the posterior capsule through dilated pupils was performed with our high-resolution digitized camera system. Standardized retroillumination images of the posterior capsule were taken 14 and 180 days after the operation. The images taken after 180 days were used for image analysis.

At 6-month follow-up, posterior capsular opacification was classified as either none, mild, moderate, or severe, depending on the number of quadrants involved. Mild PCO was recognized when it was found in only 1 quadrant. Moderate PCO occurred when it was present in 2 quadrants, and severe PCO occurred when it was found in 3 or 4 quadrants. Special attention was given to central area as they are the most important to visual acuity.

The postoperative relationship of the anterior capsulorhexis margin to the intraocular lens optic was classified as central or paracentral. The capsulorhexis rim was defined as either a regular anterior capsulorhexis or an irregular anterior capsulorhexis.

Fisher's exact test was used to analyze the difference in PCO between groups with a small and a large capsulorhexis, a central and a paracentral capsulorhexis, and regular and irregular capsulorhexis. PCO intensification was classed as either none, mild, moderate or severe. The Fisher-Freeman-Halton test and the Kruskal-Wallis test were used to analyze the difference in data between the groups with different capsulorhexis diameter, localization and shape. A *P* value of less than 0.001 was considered as statistically significant.

Before cataract extraction surgery all patients were adequately informed of the nature and possible consequences of the study and they provided signed consent for the use of medical records for research purposes.

RESULTS

There were no surgical complications that would have led to patient exclusion. For 30 days after surgery, none of the patients reported infections, and within 180 days none of them had reported any serious fever episodes.

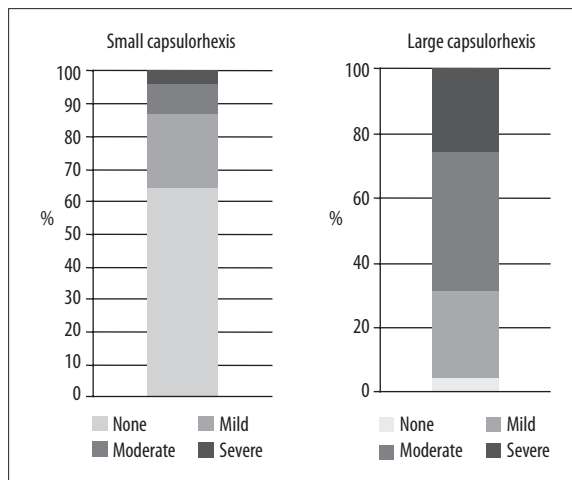


Figure 2. The amount of PCO in the groups with small and large capsulorhexis at 6 months follow-up.

The mean age was 66 years (range: 45 to 87 years) (Figure 1); 188 of the patients were female and 109 were male. There were no significant differences in age and sex distribution between the groups.

Ninety-seven patients were postoperatively recruited and assigned to each capsulorhexis size group – 44 patients (45%) were found to have a large capsulorhexis and 53 patients (55%) were found to have a small capsulorhexis. In another group of 99 patients, it was the capsulorhexis localization that was assessed. In this group, 66 patients (66%) were found to have a central capsulorhexis and 33 patients (34%) were found to have a paracentral one. In the third group, which consisted of 101 patients, the shape of the capsulorhexis rim was assessed. The first subgroup of 59 patients (58%) were found to have regularly shaped capsulorhexis rims and 42 patients (42%) were found to have irregularly shaped rims.

At the 6-month follow-up, in the group in which the capsulorhexis diameter was observed, the edge of the large capsulorhexis lay at the edge of the intraocular lens optic in 19% (8 patients), while the rest of the patients had the edge of the anterior capsulorhexis on the intraocular lens optic for 360 degrees when the capsulorhexis was small as well as in large ones.

The amount of PCO at 6 months was significantly different between the groups with small and large capsulorhexis (Figure 2) – 86.79% of the patients with a small capsulorhexis had no or mild posterior capsule opacification, whereas 68.18% of the patients with a large capsulorhexis had moderate or severe PCO. Patients with a small capsulorhexis had significantly less posterior capsular opacification than those with a large capsulorhexis (*p*<0.001) (Table 1).

The amount of PCO in the groups with central (66 patients) and paracentral (33 patients) capsulorhexis localization was similar (Figure 3) – 89.4% of the patients with a central capsulorhexis had no or mild posterior capsule opacification, whereas 75.75% of the patients with a paracentral capsulorhexis had moderate or severe PCO. Patients with a central capsulorhexis had significantly less posterior capsular

Table 1. Comparison between the groups with a small and a large capsulorhexis (Fisher's exact test, Fisher-Freeman-Halton test).

| PCO | Capsulorhexis | | | | p-value |
|--------------|---------------|---------------|-----------|---------------|------------------|
| | Small | | Large | | |
| | n | % | n | % | |
| None | 34 | 64.15 | 2 | 4.55 | <0.001 |
| Mild | 12 | 22.64 | 12 | 27.27 | 0.642 |
| Moderate | 5 | 9.46 | 19 | 43.18 | <0.001 |
| Severe | 2 | 3.77 | 11 | 25.00 | 0.002699 |
| Total | 53 | 100.00 | 44 | 100.00 | <0.001 |

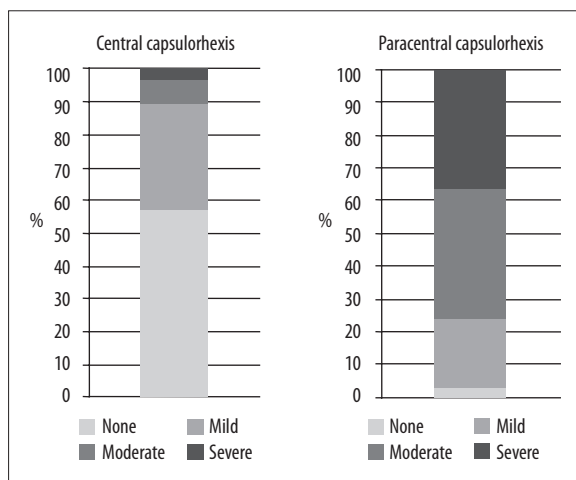


Figure 3. The amount of PCO in the groups with central and paracentral capsulorhexis localization at 6 month follow-up.

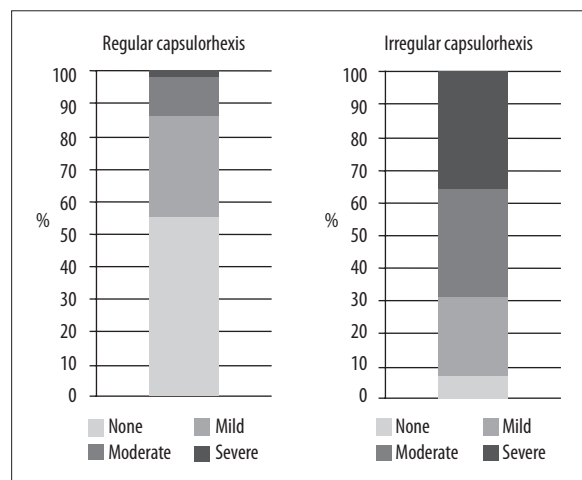


Figure 4. The amount of PCO in the groups with regular and irregular anterior capsulorhexis rim shape.

Table 2. Comparison between the groups with a central and a paracentral capsulorhexis localization (Fisher's exact test, Fisher-Freeman-Halton test).

| PCO | Capsulorhexis | | | | p-value |
|--------------|---------------|---------------|-------------|---------------|------------------|
| | Central | | Paracentral | | |
| | n | % | n | % | |
| None | 38 | 57.58 | 1 | 3.03 | <0.001 |
| Mild | 21 | 31.82 | 7 | 21.21 | 0.3463 |
| Moderate | 5 | 7.58 | 13 | 39.39 | <0.001 |
| Severe | 2 | 3.03 | 12 | 36.36 | <0.001 |
| Total | 66 | 100.00 | 33 | 100.00 | <0.001 |

opacification than those with a paracentral anterior capsulorhexis ($p < 0.001$) (Table 2).

Figure 4 shows the amount of PCO in the groups with regular and irregular anterior capsulorhexis rim shapes – 86.44% of the patients with a regular rim of the anterior capsulorhexis had no or mild posterior capsule opacification and 13.55% had moderate or severe PCO, while 69.04% of the patients with an irregular capsulorhexis rim

had moderate or severe PCO. Patients with a regular anterior capsulorhexis rim had significantly less posterior capsular opacification than those with an irregular anterior capsulorhexis rim ($p < 0.001$) (Table 3).

In all examined parameters the posterior capsule opacification ratio was smallest when the capsulorhexis was small, centrally located and with a regularly shaped rim when compared to the large, paracentral and irregular ones. There

Table 3. Comparison between the groups with a regular and an irregular anterior capsulorhexis rim shape (Fisher's exact test, Fisher-Freeman-Halton test).

| PCO | Capsulorhexis | | | | p-value |
|--------------|---------------|---------------|-----------|---------------|------------------|
| | Regular | | Irregular | | |
| | n | % | n | % | |
| None | 33 | 55.93 | 3 | 7.14 | <0.001 |
| Mild | 18 | 30.51 | 10 | 23.81 | 0.5056 |
| Moderate | 7 | 11.86 | 14 | 33.33 | 0.01249 |
| Severe | 1 | 1.69 | 15 | 35.71 | <0.001 |
| Total | 59 | 100.00 | 42 | 100.00 | <0.001 |

Table 4. Comparison between the groups with small, central and regular shape of the capsulorhexis (Kruskal-Wallis test).

| PCO | Capsulorhexis | | | | | | p-value |
|--------------|---------------|---------------|-----------|---------------|-----------|---------------|---------------|
| | Small | | Central | | Regular | | |
| | n | % | n | % | n | % | |
| None | 34 | 64.15 | 38 | 57.58 | 33 | 55.93 | |
| Mild | 12 | 22.64 | 21 | 31.82 | 18 | 30.51 | |
| Moderate | 5 | 9.46 | 5 | 7.58 | 7 | 11.86 | |
| Severe | 2 | 3.77 | 2 | 3.03 | 1 | 1.69 | |
| Total | 53 | 100.00 | 66 | 100.00 | 59 | 100.00 | 0.6997 |

was no statistically significant difference in the Kruskal-Wallis test results between the groups with small, central and regular shape of capsulorhexis ($p=0.6997$) (Table 4).

In the group of all operated patients, 38 (12%) of those experiencing severe postoperative posterior capsule opacification qualified for a neodymium: yttrium-aluminium-garnet (Nd: YAG) laser posterior capsulotomy.

DISCUSSION

The effect of the size of the capsulorhexis on posterior capsular opacification was investigated by Ravalico et al in a retrospective study of 107 patients who underwent extracapsular cataract extraction with capsulorhexis and capsular bag IOL implantation (polyHema IOLs and PMMA IOLs). They found that a capsulorhexis of a slightly smaller diameter than the IOL optic appears to be better than a large-size capsulorhexis in reducing the incidence of PCO [20]. Due to different cataract extraction procedures and IOL material, these results are not suitable for comparison with our research results.

A procedure similar to that used in our investigation was carried out by Hollic et al in a prospective study of 75 patients who underwent standardized phacoemulsification with capsulorhexis and in-the-bag placement of a 5.5-mm polymethylmethacrylate intraocular lens implant. The patients were randomly assigned to receive either a small capsulorhexis

of 4.5 to 5 mm to lie completely on the intraocular lens optic, or a large capsulorhexis of 6 to 7 mm to lie completely off the lens optic. They suggested that large capsulorhexis were associated with a significant increase in the wrinkling of the posterior capsule and a worse posterior capsular opacification as compared to small capsulorhexis. At 1 year, the average percentage area of posterior capsular opacification was 32.7% for small capsulorhexis and 66.2% for large capsulorhexis. Patients with large capsulorhexis experienced significantly poorer visual acuities and a trend toward worse contrast sensitivities [21].

Aykan et al found comparable results in their prospective study (496 eyes underwent standardized phacoemulsification with capsulorhexis and capsular bag foldable acrylic IOL implantation). A small (4.5 to 5.0 mm) capsulorhexis and capsular bag implantation of 5.5 mm acrylic IOL reduced PCO incidence when compared to a 6.0 to 7.0 mm capsulorhexis [22].

The effect of the position of the anterior capsulorhexis on posterior capsular opacification was investigated by Wejde et al in a study of 119 patients who underwent cataract surgery with phacoemulsification performed by a single surgeon. The patients were randomized to implantation with either a silicone intraocular lens (IOL) (SI40NB, Allergan) or an AcrySof IOL (MA60BM, Alcon). Three years following the surgery, the rate of PCO was analyzed using the evaluation of posterior capsule opacification computer software

(EPCO). The results were related to the capsulorhexis position, which was assessed with a retroillumination photograph. If the capsulorhexis was located partially or completely off the optics of the IOL as opposed to completely on the IOL, significantly more PCO was found, suggesting that the positioning of the capsulorhexis impacts the development of PCO [23].

Our results agree with earlier reports [21–23]. A relatively small and central capsulorhexis that allows the complete coverage of the IOL optics by the capsulorhexis edges seems to protect against PCO in cataract surgery. This may be explained by LEC mechanical blockade into the effect of the anterior lens capsule adhesion to the IOL, which is especially strong when there is complete anterior capsule overlap on the IOL optic in 360°.

However, Hayashi reported that in a study of 100 patients, 81% showed complete anterior capsule overlap, and there was no significant difference in the PCO value between the eyes with a complete anterior capsule overlap and those with partial or incomplete anterior capsule overlap. Furthermore, no significant correlation was found between the degree of the anterior capsule overlap and the extent of the PCO [24].

In our observations patients with a regularly shaped capsulorhexis rim had significantly less posterior capsular opacification than those with an irregular anterior capsulorhexis rim ($p < 0.001$). We believe that when the capsulorhexis rim is regular, the disintegration of forces working on the lens capsule is identical, and wrinkling is much less likely to occur. In the event that the capsulorhexis rim is irregular, forces working on the lens capsule are different, which affects posterior capsular folds. This hypothesis needs to be confirmed by further studies. Statistical analysis with the Kruskal-Wallis test shows that there was no statistically significant difference between the groups with small, central or regularly shaped capsulorhexis ($p = 0.6997$). This result shows that not only the diameter, but also the localization and the shape of the capsulorhexis has an influence on the occurrence of posterior capsular opacification, and that the degree of influence of these seems to be at a comparable level of importance.

CONCLUSIONS

This study indicates that not only a small capsulorhexis diameter, but also its central localization and its regular shape result in less posterior capsular opacification following the phacoemulsification procedure.

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