The Relationship Between Capsulorhexis Size and Anterior Chamber Depth Relation

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BACKGROUND AND OBJECTIVE: To determine whether the diameter of the capsulorhexis has an effect on anterior chamber depth (ACD) following phacoemulsification surgery.

PATIENTS AND METHODS: Fifty-one consecutive patients were selected for cataract extraction by phacoemulsification with intraocular lens (IOL) implantation. Twenty-two of 51 patients underwent 4 mm capsulorhexis, while the rest underwent 6 mm. All were implanted with a multi-piece polymethyl methacrylate posterior chamber IOL with 5.0 mm diameter biconvex optic and flexible haptic. They were followed 3 months postoperatively. The width of the capsulorhexis was assured according to the IOL optic implanted intraoperatively, and by the help of slit-lamp measurement after dilatation of the pupil on the first postoperative day. ACD and axial length (AL) of patients was obtained by ultrasonography on both the days before surgery, and the first and seventh postoperative days, and after 30, 60 and 90 days.

RESULTS: Early significant increase of ACD and ACD/AL ratios were observed in only the 6 mm capsulorhexis group on the first day postoperatively (P = .012, and P = .018). On the 90th postoperative day, ACD increased significantly both in the 4 mm (P = .002) and the 6 mm capsulorhexis groups (P = .049) when compared to preoperative values. For the same period, meaningful increase in ACD/AL ratio in the eyes with both 4 mm and 6 mm capsulorhexis groups was also noted compared with preoperatively (P = .002 and P = .019). There was a statistical difference between the 90th day ACD values of 4 mm (3.73 ± 0.32 mm, mean ± standard deviation) and 6 mm capsulorhexis groups (3.50 ±0.33 mm) (P = .028). For the same period, ACD/AL ratio was also significantly different for both groups (0.152 ±0.01, and 0.142 ±0.01 respectively) (P = .004). The refractive error changes followed the ACD changes and showed meaningful differences between 1st and 90th days postoperative values of each group (P = .029, and P = . 014, respectively).

CONCLUSION: A 4 mm capsulorhexis results in a longer postoperative ACD than does a 6 mm capsulorhexis for the IOL type used in this study.

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INTRODUCTION

As the phacoemulsification technique has improved, the recent trend in cataract surgery has been to use small polymethylmetacrylate (PMMA) or foldable posterior chamber intraocular lenses (IOL), which necessitates precise in-the-bag placement and good centration.[1] Fixation of an IOL can be assured by using continuous curvilinear capsulorhexis technique. Therefore, type and size of capsulorhexis has gained importance. The diameter of the capsulorhexis is typically smaller than the diameter of the dilated pupil, and is usually between 4.5 and 6 mm.[2]

The pseudophakic anterior chamber depth (ACD) is a major determinant for the theoretical/optical IOL power formula, and an accurate prediction of this variable is therefore important for an accurate IOL power prediction.[3] The ACD variation may cause variations in vision after cataract surgery with IOL implantation.[4] After a continuous curvilinear capsulorhexis, the intact anterior capsular rim demonstrates surprising strength and forms a barrier which prevents any anterior shifting of the lens haptics.[5] Because in-the-bag fixation can be guaranteed with continuous curvilinear capsulorhexis, the pseudophakic ACD may be less dependent on the surgical variation, and therefore more predictable.[3]

This study assessed to determine whether the size of capsulorhexis effects anterior chamber depth and anterior chamber depth/axial length (AL) ratio in multi-piece PMMA IOL implanted eyes, and also to evaluate best capsulorhexis width to achieve predicted ACD values accurately.

MATERIALS AND METHODS

Fifty-one eyes of 51 consecutive patients were selected for cataract extraction by phacoemulsification with IOL implantation in a double-masked fashion prospective study. The patients were randomly assigned preoperatively to one of two groups. The first group was comprised of 4 mm capsulorhexis size patients who were 22 in number, and the second group was 29 patients with 6 mm capsulorhexis size. Patients' ages at the time of surgery ranged from 31 to 73 years (mean 57.1 years) in the former, and 40 to 80 years (mean 58.1 years) in the latter group. Informed consent was obtained from each patient before surgery.

All patients had the same preoperative, operative, and postoperative routine. The exclusion criteria were the following: cataracts with causes other than age-related changes; history of previous ocular surgery or inflammation; eyes with any retinal morbidity; and eyes with a pupillary diameter after full dilatation of less than 6 mm.

The patients were operated on by two surgeons using the same technique. Surgery with clear corneal incision was done in each case, as described previously. The anterior chamber was entered with a clear corneal incision by using a 3.2-mm keratome. Following formation of the anterior chamber with a viscoelastic agent, capsulorhexis was initiated with a cystotome and completed with a forceps. The capsulorhexis sizes were assured according to the optic diameter of the implanted IOL (5.0 mm) intraoperatively, and also by the measurement using the variable length calibrated slit beam of the slit lamp following the full dilatation of the pupil on the first day postoperatively.

Phacoemulsification was performed with the standard divide-and-conquer technique. After completion of cortex aspiration, incision was enlarged by using 5.2-mm keratome. A 5.0 mm, biconvex, a multi-piece PMMA posterior chamber IOL (Model: 24050-125UT; Eye Technology, Inc., St.Paul, MN) with flexible haptics was placed in the capsular bag and then rotated into position. All IOLs were confirmed to be implanted accurately in the capsular bag by using an iris hook. The IOL used in the study had 5° angle between haptics, 118.1 A constant and 5 mm estimated ACD.

Following IOL insertion, the IA tip was used to irrigate and aspirate the residual viscoelastic material. Acetylcholine chloride was injected into the anterior chamber to constrict the pupil. No intraoperative complications occurred. At the end of the surgery, gentamicine and betamethasone were injected subconjuctivally. Postoperatively, the patients were maintained on a tapering dose of prednisolone sodium phosphate 1% topically.

Biomicroscopic, refractive and fundoscopic examinations, keratometry readings, B-scan studies, AL, ACD measurements were completed in all patients both preoperatively and at the 1st, 7th, 30th, 60th and 90th days postoperatively. Capsulorhexis size measurements by slit-lamp after pupil dilatation were also performed in each postoperative control. Patients who had asymmetric capsulorhexis and/or measurements other than 4 mm and 6 mm because of any complication were excluded from study. All cases with 4 mm capsulorhexis demostrated 360° overlap of the IOL optic at all times after surgery, whereas no case with a 6 mm capsulorhexis exhibited optic edge overlap. Posterior synecchiae was not noted in any case during follow-up. The AL and ACD were measured with an A-scan ultrasonography using a 10 MHz transducer after dilatation of pupil. Refractive error was expressed in its spherical equivalence value, which is calculated from the diopters of spherical lens and half the astig-

Table 1. Comparison of Mean Anterior Chamber Depth Values in 4 mm and 6 mm Capsulorhexis Groups (mm ± standard deviation)

	4 mm capsulorhexis (n=22)	6 mm capsulorhexis (n=29)	*P*
Preoperative	3.38 ± 0.32	3.40 ± 0.41	.834
1st day postoperatively	3.41 ± 0.40	3.62 ± 0.46	.046*
7th day postoperatively	3.49 ± 0.33	3.62 ± 0.45	.159
30th day postoperatively	3.63 ± 0.34	3.53 ± 0.37	.313
60th day postoperatively	3.66 ± 0.30	3.53 ± 0.36	.144
90th day postoperatively	3.73 ± 0.32	3.51 ± 0.33	.028*

**Significant ($P < 0.05$)*

Table 2. Comparison of Anterior Chamber Depth/Axial Length Ratios in 4 mm and 6 mm Capsulorhexis Groups (mean ± standard deviation)

	4 mm capsulorhexis (n=22)	6 mm capsulorhexis (n=29)	*P*
Preoperative	0.135 ± 0.02	0.134 ± 0.02	.764
1st day postoperatively	0.138 ± 0.02	0.147 ± 0.02	.041*
7th day postoperatively	0.141 ± 0.01	0.147 ± 0.02	.313
30th day postoperatively	0.149± 0.01	0.142± 0.01	.121
60th day postoperatively	0.150 ± 0.01	0.142 ± 0.01	.093
90th day postoperatively	0.152 ± 0.01	0.142 ± 0.01	.004*

**Significant ($P < 0.05$)*

matic power. Patients who failed to have one of these measurements or with any complication at the follow up visits were not included in this study. Besides ACD, the ratios of ACDAL were also calculated to eliminate the effects of individual changes.

The data was analyzed using the Wilcoxon and Mann-Whitney U-tests. The *P* value of <0.05 was considered statistically significant.

RESULTS

The mean preoperative ACD was 3.38 ±0.44 mm in the 4 mm group, and 3.40 ± 0.41 mm in the 6 mm capsulorhexis group (*P* = .834) (Table 1). Preoperative ACDAL ratios of both groups showed no difference (0.135 ± 0.02, and 0.134±0.02) (*P* = .764) (Table 2).

When preoperative and postoperative first day ACD and ACDAL values in 4 mm capsulorhexis group were considered, there was some degree of increase but these were insignificant (*P* = .974 and *P* = .445). ACD became significantly deeper only on 30 days postoperatively in this group (*P* = .013). ACDAL ratios on the 30th postoperative day also confirmed this significance (*P* = .024). In the same group, ACD and ACDAL values in the postoperative 90th day were increased meaningfully, compared with the preoperative values (*P* = .002 and *P* = .002).

In the 6 mm capsulorhexis group, ACD and ACDAL values during postoperative first day were significantly higher than in preoperative values (*P* = .012 and *P* = .018). Postoperative 90th day ACD and ACDAL values showed also significant increase compared with the preoperative values (*P* = .049 and *P* = .022). The postoperative 7th day values of ACD and ACDAL were insignificantly dropped on the 90th day (*P* = .166 and *P* = .178).

Postoperative 90th day mean ACD values were 3.73±0.32 mm in the 4 mm group, and 3.50±0.33 mm in the 6 mm capsulorhexis group (*P*=.028). There was also a significant difference between the postoperative 90th day ACDAL ratios of both groups (*P*=.004).

The mean IOL power was 21.37 ± 1.84 diopter

Table 3. Comparison of Mean Anterior Chamber Depth Values in 4 mm and 6 mm Capsulorhexis Groups (mm ± standard deviation)

	4 mm capsulorhexis (n=22)	6 mm capsulorhexis (n=29)	*P*
1st day postoperatively	1.69 ± 1.36	1.48 ± 1.24	.029*
7th day postoperatively	1.54 ± 1.27	1.47 ± 1.33	.084
30th day postoperatively	1.42 ± 1.18	1.52 ± 1.38	.285
60th day postoperatively	1.39 ± 1.16	1.50 ± 1.24	.194
90th day postoperatively	1.28 ± 1.11	1.51 ± 1.26	.014*

*Significant ($P < 0.05$)

in the 4 mm group, and 21.04 ± 2.29 diopter in the 6 mm capsulorhexis group preoperatively ($P = .849$). The postoperative variations in the mean refractive error are shown in Table 3. Refraction measured tended toward higher myopia when ACD decreased. It became more hyperopic when ACD increased.

DISCUSSION

Capsulorhexis is associated with improved IOL centration and appears to create a safer environment during phacoemulsification. It precludes contact between the active uveal and vascular elements of the anterior segment of the eye and the IOL, preventing the various manifestations of iris chafing.[7-10]

The optimal size of capsulorhexis is not known. Some surgeons favor small ones to preserve as much of the capsular sac as possible, but a small capsulorhexis may further constrict and obstruct the visual axis and even affect IOL centration.[2] A capsulorhexis that is too small makes it difficult to place the IOL properly and causes adhesions between the posterior iris and the capsule. A capsulorhexis that is too large also causes adhesions and, frequently, migration of the IOL in one direction or another.[11]

The precise behavior of the ACD after IOL implantation is uncertain.[12] Increase or decrease in ACD after posterior chamber IOL implantation has been reported.[12-14] On the other hand, the refractive effect of an IOL depends on its position within the eye. If the implant is placed more anteriorly than expected, the refraction will shift to the myopic side, and if deeper than expected, the eye will become more hyperopic than expected. The larger the variation in the postoperative ACD, the larger the eventual prediction error.[16] An error of 1 mm in the estimation of the postoperative ACD following IOL implantation causes an error of 1 diopter in postoperative refraction.[17]

In the present study, the anterior chamber depth changes and possible mechanisms that caused these include the following:

Preoperative mean ACD values and ACD/AL ratios of both groups were almost the same. Some degree of decrease in intraocular volume occurs following surgery as crystalline lens thickness is bigger than the IOL thickness.[18] In the postoperative first and seventh days, significant increase in ACD and ACD/AL ratio were observed in eyes with 6 mm capsulorhexis.

The lens capsule and zonular fibers exert opposite forces on each other to mold the shape of the lens. The zonule-free area is only 6.5 mm to 7 mm in diameter on the capsule. In the nonaccommodative state, the anterior zonules are directed anteriorly and obliquely, stretching the anterior capsule and the lens posteriorly and to the periphery.[19] The larger 6 mm capsulorhexis initially had a deeper ACD than the 4 mm capsulorhexis. A 6 mm capsulorhexis, leaving only 0.5 to 1 mm capsular area, probably interrupts capsular integrity and generates centrifugal zonule force more than 4 mm capsulorhexis does in the early postoperative period. Anteriorly angulated IOL haptics assist backward movement. In eyes with 4 mm capsulorhexis, the anterior capsule retains its integrity, and zonule forces to both the anterior and posterior capsule were more balanced.

Over the next 90 days, the 4 mm capsulorhexis eyes tended to have an increase in their ACD, and the 6 mm capsulorhexis showed some decrease in ACD (Figure 1).

There may be adhesions of anterior and posterior capsules to the IOL optics because of the retained lens epithels or fibrotic reactions of the equatorial cells. Soft haptics of the IOL used in our surgery, and that fibrotic reaction, possibly let the IOL move back in the long-term.

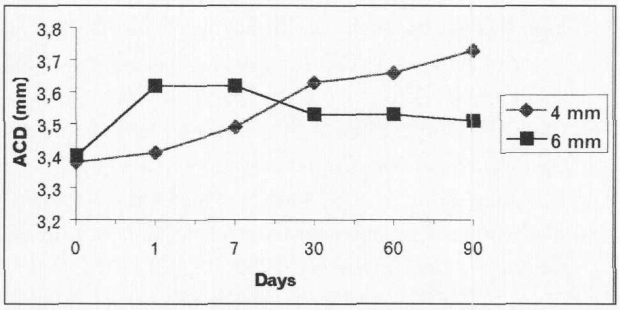

Figure 1. Anterior chamber depth alterations with the time in the groups.

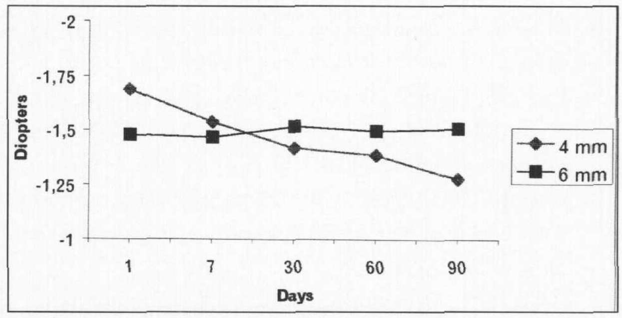

Figure 2. Postoperative refractive error in the 4 mm and 6 mm capsulorhexis groups.

There was a significant increase in the ACD/AL ratio in both groups which was noted for the same period.

When the anterior capsulorhexis is larger than the IOL diameter, IOL optics may move forward easily as the residual anterior capsular space decreases. Decrease in ACD values in the period between the postoperative 7th day and 90th day for 6 mm capsulorhexis group reminds this situation, although ACD values increased during early postoperative period. Some degree of decrease in ACD/AL ratios for the same period were also noted in this group.

In eyes with 4 mm capsulorhexis, the postoperative 90th day ACD and ACD/AL ratios seemed to increase when compared to preoperative values. Probably, we could not remove lens epithelial cells adequately during surgery, and this might be the determining factor in this study. The removal of lens epithelial cells from the anterior capsule prevents a postoperative fibrinous reaction.[20] The fibrous dysplasia of these cells may greatly enhance the contractile force of the inherently elastic capsular membrane.[21] In cases operated on with continuous curvilinear capsulorhexis, lens epithelial cells are seen along the capsulorhexis rim in the first weeks after surgery.[22] The larger rim may mean the larger reaction generating more powerful centripetal capsular force in the late postoperative period.

Arai et al.[4] states that 5° to 10° forward angled haptics pushes the IOL with 6.5 mm optic posteriorly upon fixation from 6 mm capsulotomy in the capsular bag when the bag shrinks. Furthermore, we suggest that when time elapses, continued contraction of the capsular sac after surgery causes the IOL to shift forward if the capsulotomy does not overlap the optic, and to pull posteriorly if the capsulotomy overlaps the optic.

In the present study, refractive error changes occurred after the ACD changes and more or less showed the correlation between 1 mm and 1 diopter. Figure 2 shows mean refractive error changes according to different capsulorhexis sizes.

Although ACD and ACD/AL parameters increased significantly at the end of 90th postoperative day in both capsulorhexis groups, deeper ACD was achieved with a smaller capsulorhexis. The 4 mm capsulorhexis more closely approximates the predicted 5.0 mm ACD of the IOL type used in the present study (Figure 1). For reasons based on our personal experience, when the capsulorhexis is smaller than the IOL optic one-piece PMMA IOL, there seems to be more appropriate reducing postoperative unwanted results. Further study is needed to clarify the effect of one-piece PMMA IOL with different sized optic and capsulorhexis on ACD changes.

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