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Original Article

Weighted Comparison of the Corneal Topographic Data in Intracapsular versus Ciliary Sulcus Intraocular Lens Implantation during Phacoemulsification Surgery

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Abstract

Objectives: This study aimed to evaluate the preoperative and postoperative changes in corneal topography, intraocular pressure (IOP), and visual acuity in patients who developed posterior capsule rupture during phacoemulsification surgery and simultaneously underwent ciliary sulcus intraocular lens (IOL) implantation and in those with intact capsular integrity who simultaneously underwent intracapsular IOL implantation and to compare these changes within and between the two groups.

Methods: Among the 855 patients, 92 eyes of 69 patients whose corneal topography, IOP, and best-corrected visual acuity (BCVA) were successfully measured were included in the study. Preliminary chamber parameters [horizontal visible iris diameter (HVID), iridocorneal angle, anterior chamber volume (ACV), and anterior chamber depth (ACD)] were measured before and after surgery using a Sirius corneal topography device.

Results: The IOL was implanted in the capsular bag in 58 patients and in the ciliary sulcus between the posterior iris and the capsule in 34 patients. In the sulcus IOL group, both BCVA and IOP measurements statistically significantly increased in the postoperative period compared with the preoperative values ($p<0.001$). As regards postoperative changes between the intracapsular and sulcus IOL groups, no significant difference was found in the changes in HVID ($p=0.584$), iridocorneal angle ($p=0.282$), and ACD ($p=0.382$), whereas the changes in ACV, IOP, and BCVA were statistically significantly different ($p=0.020$, $p<0.001$, and $p<0.001$, respectively).

Conclusion: While the IOP of the sulcus IOL group significantly increased, that of the intracapsular group significantly decreased. Visual acuity increased in both lens implants, but patients with intracapsular lenses had greater improvement in visual acuity; thus, intracapsular IOL implantation was more advantageous than sulcus IOL implantation.

Keywords: Corneal tomography, intraocular lens, intraocular pressure, phacoemulsification surgery, visual acuity.

Introduction

For the past three decades, lens extraction has been the most performed operation in patients aged >65 years (1). Intraocular lens (IOL) implantation has become a routine application in almost all lens extractions because of its optical advantages and very few complications (2). Posterior capsule rupture and vitreous loss are among the most important complications of modern extracapsular cataract surgery.

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After posterior capsule rupture, the surgeon can terminate surgery using one of the two different methods: leaving the patient aphakic without implanting an intraocular lens and performing secondary IOL surgery in another session or implanting a one-piece polymethyl methacrylate (PMMA) lens in the ciliary sulcus during the same session in patients with an intact capsule. However, these one-piece hard lenses placed in the ciliary sulcus can push the iris forward and may increase the intraocular pressure (IOP) as a result of a decrease in the anterior chamber volume (ACV) (3).

To the best of our knowledge, no study has compared the effects of lenses placed in the sulcus and those placed in the capsular bag on anterior segment structures using corneal topography. Therefore, in this study, we aimed to evaluate the preoperative and postoperative changes in corneal topography, IOP, and visual acuity in patients who developed posterior capsule rupture during phacoemulsification surgery and simultaneously underwent IOL implantation in the ciliary sulcus and in those with intact capsular integrity who underwent intracapsular IOL implantation and to compare the effects of the PMMA intraocular lens implanted in the sulcus and the acrylic intraocular lens implanted in the capsular bag on the aforementioned parameters.

Methods

Among the 855 patients who underwent cataract surgery between September 2011 and December 2012 at the Turkish Ministry of Health Dr. Lutfi Kirdar Kartal Training and Research Hospital Eye Clinic, 92 eyes of 69 patients whose corneal topography, IOP, and best-corrected visual acuity (BCVA) were successfully measured were included in the study.

The Institutional Review Board of the hospital approved the study. The study was carried out in accordance with the principles of the Declaration of Helsinki. Written and verbal informed consent was obtained from each patient before the procedure.

For preoperative pupillary dilation, 0.5% cyclopentolate and 0.5% tropicamide were used in all patients through instillation three times at an interval of 5 min. For anesthesia, 2% lidocaine was used topically and intracamerally during surgery. As a standard procedure, in all patients, a side port entry was made at 2 and 9 o'clock positions, and a 2.8-mm corneal incision was performed from the upper temporal region. Capsulorhexis was undertaken in all patients using a cystotome. Sodium hyaluronate (29.2 mg/ml) and sodium chondroitin sulfate (37 mg/ml) (Viscoat, Alcon Surgical, Inc., Ft. Worth, TX, USA) were used as viscoelastic agents. Biaxial phacoemulsification surgery (Stellaris, Bausch & Lomb, Rochester, NY, USA) was performed in all eyes; furthermore, during the same surgical session, the IOL was implanted in the capsular bag in 58 patients and in the ciliary sulcus between the posterior iris and the capsule in 34 patients. Anterior vitrectomy was performed in patients in the sulcus IOL group who developed posterior capsule rupture. The intracapsular IOL was an aspheric foldable hydrophobic monocular acrylic lens (Acriva UD 613, VSY Biotechnology, Istanbul, Turkey), whereas the IOL implanted in the sulcus was a one-piece PMMA lens (Omni UVCH65-130, Omni Lens, Ahmedabad, India). In the sulcus IOL group, PMMA lenses were placed by expanding the incision site in the same surgical session in all patients. No lens other than PMMA was used in the sulcus IOL group. In this group, 1–3 sutures were placed in the corneoscleral incision area when terminating the surgery. No suture was placed in the incision site in any of the patients in the intracapsular IOL group. Cefuroxime at a concentration of 1 cc 1 gr/0.1 ml was administered to the anterior chamber for prophylaxis.

All patients were prescribed six daily drops of 10 mg/ml (1%) acetate (Pred forte; Allergan, Irvine, CA, USA) and four daily drops of 3 mg/ml lomefloxacin (Okacin, Alcon, Ft. Worth, TX, USA) for 3 weeks postoperatively. Detailed biomicroscopic, IOP, and fundus examinations were performed before and after surgery on the first day, first week, first month, and second month.

The sutures in the sulcus IOL group were removed on postoperative day 30. The eyes of all patients were evaluated before surgery and on postoperative day 60 in terms of anterior chamber parameters [horizontal visible iris diameter (HVID), iridocorneal angle, ACV, and anterior chamber depth (ACD)] using a CSO Sirius corneal topography device (CSO, Firenze, Italy). In addition, before surgery and on postoperative day 60, the IOP was measured with Goldmann applanation tonometry and evaluated after calculating pachymetric thicknesses. Using a Snellen chart, BCVA and uncorrected visual acuity were determined in all patients before and after surgery.

Patients who had more than three sutures or implanted with foldable IOLs in the sulcus were not included in the study. In addition, of the patients in whom sutures were removed on day 30, those who presented with wound dehiscence and those whose sutures could not be removed on the specified day were excluded. Further excluded were patients who had a history of intraocular surgery or eye trauma, those with corneal anterior and posterior irregularities, those aged < 45 years, those with systemic diseases, those who were unable to regularly attend follow-up, those whose anterior capsule was not intact during examination, those with a tilted IOL, and those with an anterior chamber reaction or no regression in corneal edema despite treatment.

Statistical Analysis

Preoperative and postoperative corneal topography data, IOP measurements, and BCVA values were statistically eval-

uated both within and between the two groups. All statistical analyses were performed using IBM SPSS Statistics software version 18 (IBM Corp., Armonk, NY, USA) at 95% confidence interval and significance level of p<0.05. The t-test and Wilcoxon test were used in the analysis of dependent variables, and the Mann–Whitney U test was used in the analysis of independent variables.

Results

Overall, the mean patient age was 64.8±12.24 years, and the mean ages of the intracapsular and sulcus IOL groups were 64.6±12.94 and 65.1±13.16 years, respectively. A total of 92 eyes of 69 patients (36 women, 33 men) were included in the study. Intracapsular IOL implantation was performed in 58 eyes, while the IOL was implanted in the sulcus between the posterior iris and the capsule in 34 eyes. No IOL tilt or decentralization was observed in any case.

The comparisons of parameters before and after surgery in all cases are shown in Table 1. The results revealed that the iridocorneal angle was significantly increased after surgery compared with before surgery (p<0.001). The iridocorneal angle was 41.10° preoperatively and 46.6° postoperatively, and it increased after surgery when all cases were considered. The mean ACV was 150.3 mm^3 preoperatively and 185.6 mm^3 postoperatively, showing a statistically significant increase (p<0.001). The ACD was 3.29 mm before surgery and 3.69 mm after surgery, indicating a statistically significant increase (p<0.001). The change in BCVA was statistically significant in the whole sample, and visual acuity was significantly improved after surgery (p<0.001).

The comparison of the preoperative and postoperative data within the intracapsular IOL group is shown in Table 2. Results revealed that the mean iridocorneal angle increased from 39.60° preoperatively to 46.28° postoperatively, and this change was statistically significant (p<0.001). Similarly, in this group, the changes in ACV, ACD, IOP, and BCVA were statistically significant (p<0.001).

The intragroup comparison of the sulcus IOL group revealed statistically significant changes in the iridocorneal angle and ACD from the preoperative to the postoperative period, with both values significantly increasing after surgery (p=0.016 and p=0.006, respectively) (Table 3). While the mean of the iridocorneal angle was 43.6° before surgery, it increased to 47.3° after surgery. Similarly, the mean ACD increased from 3.40 mm preoperatively to 3.69 mm postoperatively. When the BCVA and IOP measurements were evaluated within the sulcus IOL group, both values statistically significantly increased in the postoperative period compared with the preoperative measurements (p<0.001). Interestingly, while the mean IOP was 15.4 mmHg preoperatively, it

Table 1. Comparison of the corneal tomographic data, IOP and BCVA of all patients before and after surgery

	Preoperative mean (min-max)	Postoperative mean (min-max)	P
HVID	11.74 (10.55–13.41)	11.82 (10.69–13.46)	P=0.080
Iridocorneal angle	41.10 (23–65)	46.66 (22–62)	P<0.001
Anterior chamber volume (mm^3)	150.37 (88-442)	185.62 (97–822)	P<0.001
Anterior chamber depth (mm)	3.29 (2.31–4.38)	3.69 (2.58-5.33)	P <0.001
IOP (mmHg)	16.37 (11–24)	16.28 (8-23)	P=0.814
BCVA	0.24 (0.05–0.5)	0.81 (0.5–1)	P<0.001

HVID: Horizontal visible iris diameter, IOP: intraocular pressure, BCVA: Best-corrected visual acuity.

Table 2. Intragroup comparison of the preoperative and postoperative corneal tomographic data, IOP and BCVA of the patients in the intracapsular IOL group

	Preoperative mean (min-max)	Postoperative mean (min-max)	P
HVID	11.77 (10.74–13.41)	11.87 (10.83–13.46)	P=0.256
Iridocorneal angle (°)	39.60 (23–65)	46.28 (22–62)	P<0.001
Anterior chamber volume (mm^3)	149.34 (88-442)	204.34 (99–822)	P<0.001
Anterior chamber depth (mm)	3.22 (2.31–4.38)	3.69 (2.58-5.33)	P<0.001
IOP (mmHg)	16.91 (11–24)	14.62 (8-22)	P<0.001
BCVA	0.25 (0.05–0.5)	0.86 (0.6–1)	P<0.001

IOL: intraocular lens, HVID: Horizontal visible iris diameter, IOP: intraocular pressure, BCVA: best-corrected visual acuity.

Table 3. Intragroup comparison of the preoperative and postoperative corneal tomographic data, IOP and BCVA of the patients in the sulcus IOL group

	Preoperative mean (min-max)	Postoperative mean (min-max)	P
HVID	11.68 (10.55–12.49)	11.72 (10.69–12.44)	P=0.174
Iridocorneal angle (°)	43.65 (31–65)	47.32 (31–62)	P=0.016
Anterior chamber volume (mm^3)	152.12 (89-285)	153.68 (97–240)	P=0.326
Anterior chamber depth (mm)	3.41 (2.64–4.34)	3.69 (2.82–4.45)	P=0.006
IOP (mmHg)	15.44 (11–21)	19.12 (12-23)	P<0.001
BCVA	0.22 (0.05–0.4)	0.71 (0.5–0.9)	P<0.001

IOL: intraocular lens, HVID: Horizontal visible iris diameter, IOP: intraocular pressure, BCVA: best-corrected visual acuity.

reached 19.1 mmHg postoperatively, indicating a statistically significant increase (p<0.001).

When the postoperative changes were compared between the intracapsular and sulcus IOL groups, no significant difference was found in the changes in HVID (p=0.584), iridocorneal angle (p=0.282), and ACD (p=0.382), whereas changes in ACV, IOP, and BCVA were statistically significantly different between the two IOL groups (p=0.020, p 0.001, and p<0.001, respectively) (Table 4). ACV significantly increased in the intracapsular IOL group, while it was almost the same as the preoperative value in the sulcus IOL group (Table 5). In addition, the BCVA of both groups statistically significantly improved after surgery compared with that before surgery, but this increase was more evident in the intracapsular IOL group.

Discussion

At present, phacoemulsification surgery is the latest and standard treatment for cataract extraction. Despite it minimal complications, posterior capsule rupture is one of the most important problems that can develop during this surgery. Posterior capsule rupture prolongs the operation time and makes the patient susceptible to high-risk complications, such as cystoid macular edema and retinal detachment (4).

While some surgeons leave patients with capsule rupture aphakic and plan secondary IOL implantation at a later stage, others choose to implant a PMMA lens or an acrylic three-piece PMMA haptic lens in the ciliary sulcus after anterior vitrectomy if there is adequate capsule support. However, lenses placed in the ciliary sulcus can have some unexpected effects and cause complications in intraocular structures and visual acuity because of their structure and location. Sulcus-implanted lenses can push the iris root forward and decrease ACV, narrow the anterior chamber angle, and increase IOP, thereby causing glaucoma (5). Through the same mechanism, lens haptics and optics rub against the iris stroma and stimulate inflammation, which results in pigment dispersion and associated glaucoma (6). This can also trigger uveitis by stimulating inflammation (6).

To our best knowledge, this is the first study that examined the changes in corneal topographic data before and after surgery using a Sirius corneal topography device in patients who developed posterior capsule rupture and underwent PMMA IOL implantation in the ciliary sulcus with adequate anterior capsule support and those who received an IOL implant in the capsular bag after successful phacoemulsification surgery. Important findings were also obtained.

In this study, the ACV of the intracapsular IOL group

Table 4. Comparison of the postoperative changes in the corneal tomographic data, IOP and BCVA between the intracapsular and sulcus IOL groups

	Intracapsular IOL Mean (min-max)	Sulcus IOL Mean (min-max)	P
HVID	11.87 (10.83–13.46)	11.72 (10.69–12.44)	P=0.584
Iridocorneal angle (°)	46.28 (22–62)	47.32 (31–62)	P=0.284
Anterior chamber volume (mm^3)	204.34 (99–822)	153.68 (97–240)	P=0.020
Anterior chamber depth (mm)	3.69 (2.58-5.33)	3.69 (2.82–4.45)	P=0.382
IOP (mmHg)	14.62 (8-22)	19.12 (12-23)	P<0.001
BCVA	0.86 (0.6–1)	0.71 (0.5–0.9)	P<0.001

IOL: intraocular lens, HVID: Horizontal visible iris diameter, IOP: intraocular pressure, BCVA: best-corrected visual acuity.

Table 5. Comparison of difference between preoperative and postoperative values in the corneal tomographic data, IOP and BCVA between the intracapsular and sulcus IOL groups

	Intracapsular IOL	Sulcus IOL	P
HVID	0.10	0.04	P=0.584
Iridocorneal angle (°)	6.68	3.67	P=0.284
Anterior chamber volume (mm^3)	55	1.54	P=0.020
Anterior chamber depth (mm)	0.47	0.28	P=0.382
IOP (mmHg)	-2.29	3.68	P<0.001
BCVA	0.61	0.49	P<0.001

IOL: intraocular lens, HVID: Horizontal visible iris diameter, IOP: intraocular pressure, BCVA: best-corrected visual acuity.

significantly increased after surgery, while almost no change was observed in the ACV of the sulcus IOL group. In a prospective study that examined the anterior segment changes in patients who underwent intracapsular foldable IOL implantation using ultrasound biomicroscopy, Pereira et al. (7) reported that ACV increased and the iridocorneal angle significantly expanded after surgery. Similarly, Şimşek et al. (8) evaluated preoperative and postoperative corneal topography measurements in cases in which they successfully performed phacoemulsification surgery and found that ACV significantly increased in the postoperative period. This is consistent with the increase we observed in the ACV of patients who underwent successful phacoemulsification surgery in the present study. However, the absence of an increase in our sulcus IOL group may be due to the implantation of PMMA lens in the sulcus, which pushed the posterior part of the iris forward.

Interestingly, in the sulcus IOL group, the mean IOP increased from 15.4 mmHg preoperatively to 19.1 mmHg postoperatively, indicating a statistically significant increase. In contrast, in the intracapsular IOL group, IOP decreased from 16.9 mmHg preoperatively to 14.6 mmHg postoperatively. Kampmeier et al. evaluated IOP measurements after the extraction of extracapsular cataract, followed by sulcus and intracapsular IOL implantation, and found that IOP increased in the early operative period, but 2 months after surgery in both groups, the IOP decreased compared with values before surgery. Lastly, IOP was 1 mmHg lower in the sulcus group than in the intracapsular group (9). The two studies obtained different results. The increase in the IOP of the sulcus IOL group may have been caused by the PMMA lens pushing the iridocorneal angle forward and narrowing it due to the location of the lens or it may have resulted from pigment dispersion and inflammatory cells blocking this angle. Laurell et al. examined rabbit eyes, implanted IOLs in the sulcus in one group and in the capsular bag in another group, and measured the prostaglandin E2 and leukocyte levels in the humorous aqueous on days 1, 3, 7, 28, and 56. They concluded that these levels were higher in sulcus IOL implantation and triggered inflammation (10). The results of this study can also explain the postoperative increase in the IOP of our study group in which the IOL was placed in the sulcus. In another study, Amino and Yamakawa (11) found that the number of anterior chamber flares was higher in patients with sulcus IOL implants than in those with intracapsular IOL implants. In the sulcus group, the lens optics came into contact with the posterior part of the iris, which could be possibly prevented with a wide haptic angle. In the same study, histopathological changes in the trabecular meshwork and ciliary body were also observed (11).

In patients who have developed posterior capsule rupture, placing the haptic in the sulcus and optic in the capsule may be an alternative technique (12). This method resembles intracapsular IOL implantation and reduces the risks of rubbing between the IOL and the iris and IOL decentralization (12). This method can also decrease the possibility of an IOP increase as we have detected in our sulcus group. In extracapsular cataract extraction surgery, several studies have reported that the larger incision site and suturing techniques can cause damage to angle elements, especially the trabecular tissue, scarring in the long term, and an increase in aqueous outflow resistance (13,14). This could also explain the increased IOP and reduced ACV in our sulcus group.

In the present study, when the mean BCVA was evaluated, all patients had significantly increased postoperative BCVA compared with preoperative BCVA; however, the increase in the intracapsular IOL group was higher than that in the sulcus IOL group. In phacoemulsification surgery, the most common intraoperative complication that adversely affects postoperative visual acuity is posterior capsule rupture with or without vitreous loss (15). Önal et al. compared a group of patients who developed posterior capsular tear during phacoemulsification surgery with a control group, Önal et al.reported final visual acuity of ≥0.5 as 82.7% and

93%, respectively, and found significant difference between the two groups (16). In a prospective 1,000-case series that evaluated intraoperative complications of phacoemulsification surgery, Ng et al. (17) determined that patients who developed posterior capsule tear had a 3.8 times greater risk of having a postoperative BCVA of ≤0.5 and that a posterior capsule tear was a risk factor that reduced visual acuity during cataract surgery. In the same study, the authors reported 80% as the postoperative rate of BCVA of ≥0.5 in the group with posterior capsule tear without vitreous loss, 54% in the group with vitreous loss, and 90% in the uncomplicated group. Our findings are in agreement with the results of these studies in that the level of vision was lower in our sulcus IOL group than in our intracapsular IOL group. Anterior vitrectomy performed in the sulcus IOL group may have led to this result.

In summary, we investigated the effect of IOL implantation site on IOP, visual acuity, and corneal topographic data in patients who underwent phacoemulsion surgery and IOL implantation simultaneously. In this study, we found a significant increase in the IOP of cases in which the IOL was placed in the sulcus, while the IOP of the intracapsular group significantly decreased after surgery. In addition, visual acuity increased in both lens implantation procedures, but patients with an intracapsular IOL had higher visual acuity. In conclusion, our results indicate that intracapsular IOL implantation is more advantageous than sulcus IOL implantation.

Disclosures

Ethics Committee Approval: The Institutional Review Board of the Turkish Ministry of Health Dr. Lutfi Kirdar Kartal Training and Research Hospital (2011).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Involved in design and conduct of the study (MK, SG, KÇ); preparation and review of the study (MK, SG, MA); data collection (MK, SG, KÇ); and statistical analysis (MK, SG, AE).

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