Changes in Intraocular Pressure and Anterior Chamber Parameters Following Cataract Surgery, Vitrectomy and Combined Surgery

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Abstract

**Purpose:** The aim of this study is to investigate changes in intraocular pressure (IOP) and anterior segment parameters before and after cataract surgery, vitrectomy, and combined surgery.

**Methods:** The records of patients who had undergone cataract surgery (cat group), vitrectomy (vit group), or combined cataract surgery and vitrectomy (combi group) at our hospital were retrospectively examined. Vit group consisted of Pseudophakic eyes. IOP and anterior segment measurements, including anterior chamber depth (ACD), angle opening distance (AOD), trabecular-iris angle (TIA), and trabecular-iris space area (TISA), were measured using swept-source anterior segment optical coherence tomography before and six months after surgery in 41, 15, and 40 eyes, respectively.

**Results:** In the cat and combi groups, there was a decrease in IOP from 15.8 mmHg to 13.4 mmHg and from 15.8 mmHg to 14.2 mmHg (p<0.001 and 0.002) and an increase in the central corneal thickness after surgery (p<0.001, respectively). The ACD increased in all groups, with a smaller increase in the vit group (p<0.030, respectively). Postoperative AOD, TIA, and TISA were significantly increased from in the cat and combi groups (p<0.02, respectively). Higher preoperative IOP and larger IOP reduction after surgery were correlated with smaller preoperative AOD, TISA, and TIA in cat and combi group (p<0.034, respectively). A small preoperative ACD was related to smaller preoperative AOD, TISA, TIA, (Pearson’s correlation coefficient \( r > 0.649, p<0.001 \), respectively) and postoperative IOP reduction in the cat and combi groups (\( r=0.377, p=0.018 \) and \( r=0.559, p=0.001 \)).

**Conclusion:** Compared to the vit group, the cat and combi groups showed reduced postoperative IOP and increased AOD, TISA, and TIA. In these two groups, patients with shallower preoperative ACDs showed greater changes in IOP after surgery. Changes in IOP after surgery are thought to be related to changes in the anterior segment caused by the removal of the crystalline lens.

**Keywords:** Cataract extraction, Vitrectomy, Anterior segment, Intraocular pressure
INTRODUCTION

Many studies have been conducted on postoperative changes following cataract surgery as it is the most commonly performed ophthalmic surgery. It has been widely reported that the anterior chamber deepens, and intraocular pressure (IOP) decreases after cataract surgery. Several reports have shown that as the crystalline lens volume decreases, the anterior chamber deepens, and the anterior chamber angle increases in eyes that undergo cataract surgery.\textsuperscript{[1,2]} However, the exact mechanism underlying reduced postoperative IOP has not yet been elucidated. The inflammatory effects of fibrosis, changes in the ciliary body, and anatomical changes in the anterior segments are believed to play important roles in this mechanism.\textsuperscript{[3]}

There are controversial results regarding postoperative changes in the IOP and anterior chamber angle following vitrectomy. Some reports have confirmed a significant increase in IOP after pars plana vitrectomy, whereas other studies have shown no significant postoperative changes in IOP.\textsuperscript{[4-7]} Only a few studies have been conducted on changes in the anterior segment structures after vitrectomy.\textsuperscript{[8,9]}

Various studies have been conducted to measure changes in the anterior segment after cataract surgery and vitrectomy, using slit-lamp examination, gonioscopy, ultrasound biomicroscopy (UBM), and anterior segment optical coherence tomography (AS-OCT). Anterior segment examination using AS-OCT showed similar results and accuracy to UBM. Recently, with the development of AS-OCT, more accurate analysis of the anterior segment parameters has become possible.\textsuperscript{[10,11]}

To the best of our knowledge, there is no consensus regarding the changes in anterior segment measurements before and after vitrectomy or phacovitrectomy. Thus, the present study aimed to compare changes and relationships between the IOP and anterior chamber parameters measured using swept-source AS-OCT in patients who had undergone cataract surgery, vitrectomy, or combined surgery.

MATERIALS AND METHODS

Study subjects

This study was performed in accordance with the tenets of the Declaration of Helsinki and approved by the Institutional Review Board of Pusan National University Hospital (IRB No. 05-2022-218). All patients were provided with written informed consent after they were apprised of the surgical procedure and their information. The medical records of patients who underwent cataract surgery, vitrectomy, or combined surgery at Pusan National University Yangsan Hospital between January 2021 and August 2022 and were followed up for more
than six months were retrospectively reviewed and consecutively enrolled.

Patients were categorized into the cataract surgery group (cat group), simple vitrectomy group (vit group), and combined cataract surgery and vitrectomy group (combi group), according to the surgical procedure performed on each patient. The vit group included all the pseudophakic eyes. To exclude the influence of underlying factors on IOP, vitrectomy was performed only in patients with an epiretinal membrane (ERM) and macular hole (MH), and cataract surgery was performed only in patients without vascular proliferative complications. ERM was defined as a thin membrane covering the front of the retina observed on OCT and fundus, and MH was defined as a full-thickness central foveal hole observed on fundoscopy with a defect of the entire retinal layer confirmed on OCT. The exclusion criteria were as follows (1) presence of ocular diseases other than ERM and MH in the combi and vit groups; (2) history of ocular trauma; (3) high myopia (spherical equivalent ≥-6.0 diopters or axial length ≥26 mm); (4) ocular conditions such as retinal detachment and intraocular inflammation that may affect IOP; (5) patients with glaucoma or preoperative hypertension (IOP>21 mmHg); (6) patients with ocular neovascularization including ischemic retinal vein occlusion and proliferative diabetic retinopathy, except for age-related macular degeneration; (7) patients with corneal opacity, keratoconus, keratopathy, or keratitis within the last six months; (8) patients with other media opacities; (9) silicone oil used during vitrectomy.

**Surgical technique**

In the cat group, phacoemulsification was performed using the Infinity Vision System (Alcon Laboratories, Inc., Fort Worth, TX, USA) with a 19-gauge phacoemulsification tip. After implantation of the intraocular lens (IOL), the viscoelastics were removed by placing an irrigation and aspiration cannula under the IOL. A 25-gauge 3-port pars plana vitrectomy was performed by a single surgeon (S.M.L.) using the Constellation Vision System (Alcon Laboratories, Inc., Fort Worth, TX, USA). The vitreous was removed as much as possible from the ora serrata, and assistance with the indentation technique was used if visualization of the ora serrata was not possible. In some cases, room air or 18% sulfur hexafluoride (SF6) was used for tamponade when needed. In the combi group, phacoemulsification was performed in phakic patients with an age of 50 years or more or with a preoperative nuclear opalescence grade of three or higher on the Lens Opacities Classification System III. The surgical method was the same as that used for the cat group and was performed before vitrectomy.

**Ocular parameter measurements**

Anterior segment changes following ocular surgery
All patients underwent a comprehensive ophthalmologic examination, including measurement of the best-corrected visual acuity (BCVA), IOP with a non-contact tonometer (TX-20, Canon, Tokyo, Japan), refractive error converted to the spherical equivalent, fundus examination, axial length using partial coherence laser interferometry (IOL Master 500, Carl Zeiss Meditec AG, Jena, Germany), and anterior segment parameters using swept-source AS-OCT (CASIA2, Tomey Corporation, Nagoya, Japan) at the initial visit. IOP and AS-OCT were assessed at each follow-up visit at one, three, and six months.

Anterior segment parameters, including the central corneal thickness (CCT), anterior chamber depth (ACD), lens thickness (LT), angle-to-angle distance (ATA), lens vault (LV), and anterior chamber angle-associated parameters at 500 μm and 750 μm were measured by AS-OCT. The angle opening distance (AOD), trabecular-iris space area (TISA), and trabecular-iris angle (TIA) were defined as the anterior chamber angle-associated parameters. The analyzed parameters are described in Fig. 1 and calculated by using embedded automated algorithms in the SS-OCT. Each of parameters was defined as follows. ACD is the maximum distance between the corneal endothelium and the anterior surface of the lens. LV is the distance between the horizontal line passing the anterior pole of the crystalline lens and the horizontal line joining the two scleral spurs. ATA is the distance between the angle recesses. AOD is the length of the line perpendicular to the cornea between the iris and the cornea. TISA is the trapezoidal area with anterior border of the AOD line, posterior border of a line perpendicular to the inner scleral wall to the opposing iris at the scleral spur, superior border of corneoscleral wall, and inferior border of the iris surface. TIA is the angle at the apex of a triangle with the angle recess as the vertex and the AOD line as the base. AOD, TISA and TIA were measured at distances of 500μm and 750μm from the scleral spur.

The values of each parameter were obtained automatically using an embedded program on the device. If the contour of the structures was ambiguous and could not be measured automatically, the location of the main structures was manually specified on a zoomed-in image magnified by more than 200%. The AOD, TISA, and TIA were averaged from the nasal and temporal values obtained in the horizontal direction.

**Statistical analysis**

The BCVA measured using the Snellen chart was converted to the logarithm of the minimum angle of resolution (logMAR) scale. Sex and the laterality of the eyes were compared using the chi-square test, and continuous variables such as the BCVA, refractive error, axial length, IOP, and anterior segment parameters were compared among the three groups using a one-way analysis of variance (ANOVA). Scheffé’s test was used for
post-hoc test. A paired t-test was used for preoperative and postoperative comparisons of continuous variables in each group, and Pearson’s correlation analysis was performed to determine the correlation between each factor. Multiple regression analysis was performed on ACD, LT, and LV to identify factors affecting the anterior chamber angle-associated parameters at 750 μm. In the multiple regression analysis, if the tolerance was less than 0.1 or the variance inflation factor was greater than 10, multicollinearity was considered, and the items with multicollinearity were removed. Multiple regression analyses were performed using both forward and backward selection, and the method that provided the most appropriate results was selected. Statistical analyses were performed using SPSS for Windows version 23.0 (SPSS Corp., Armonk, NY, USA). A p-value of <0.05 was considered statistically significant.

RESULTS

There were 41, 15, and 40 eyes in the cat, vit, and combi groups, respectively. Regarding baseline characteristics (Table 1), there was no significant difference between groups, except for age. The cat group was older than the combi group (post-hoc Scheffé test, p<0.019). There was a significant decrease in IOP at one and six months from 15.8 ± 1.8 mmHg to 13.7 ± 2.3 mmHg and 13.4 ± 2.0 mmHg in the cat group and from 15.8 ± 3.3 mmHg to 14.4 ± 3.3 mmHg and 14.2 ± 2.5 mmHg in the combi groups (p<0.001; p=0.026 and 0.002).

Changes of anterior segment parameters and anterior chamber angle associated parameters

CCT increased at one and six months after surgery compared to baseline in the cat and combi groups (p<0.001, respectively; Table 2, Fig. 2). However, CCT was decreased at six months compared to that at one month (p<0.001 and=0.003) in both groups. ACD increased at six months in all groups (p<0.030; Table 2, Fig. 2). The increase in the vit group was relatively small compared with that in the other two groups (post-hoc Scheffé’s test, vit group vs. cat group, and vit vs. combi group: p=0.02 and 0.028). ATA showed no significant changes in any of the groups. LV moved backward at six months in the cat and combi groups (p<0.001; Table 2). AOD, TISA, and TIA increased compared to baseline in both the cat and combi groups (p<0.02; Table 2, Fig. 3).

The preoperative parameters of preoperative ACD, AOD 500, AOD 750, TISA 500, TISA 750, TIA 500, and TIA 750 in the vit group were significantly higher than those in the cat and/or combi groups (p<0.001, <0.001, 0.003, 0.010, 0.047, 0.002, 0.013, and 0.017, respectively; Table 2), whereas the preoperative LV of the vit group was significantly lower (p<0.001). Preoperative IOP and CCT showed no significant differences among the three
groups.

**Association between IOP changes and factors**

In the cat and combi groups, IOP reduction during six months was correlated with a smaller preoperative AOD, TISA (except for TISA500 of the cat group), and TIA (p <0.038, respectively, Table 3). There was no correlation between IOP changes and changes of the anterior chamber angle-associated parameters. Preoperative IOP of cat and combi groups was negatively correlated with preoperative AOD, TISA (except for TISA 500 in the cat group), and TIA (except for TIA 500 in the combi group) (-0.478<r<-0.336, p<0.037, respectively). Postoperative IOP had no correlations with the postoperative AOD, TISA and TIA in all groups.

A small preoperative ACD was related to postoperative IOP reduction in the cat and combi groups at six months (r=0.377 and 0.559, p=0.018 and 0.001, respectively).

**Association between anterior segment parameters and anterior chamber angle associated parameters**

Preoperative LV was correlated with preoperative AOD, TISA (except for TISA 500), and TIA (r<-0.552, p<0.003), and LV at six months was correlated with changes in AOD, TISA, and TIA (r>0.534, p<0.004) in the cat group.

Preoperative LT was related to preoperative AOD, TISA, and TIA, and changes of AOD, TISA, and TIA in the combi group (r<-0.682, p<0.001, and r>0.492, p<0.004, respectively).

The preoperative ACD in the cat and combi groups was associated with preoperative AOD, TISA (except for TISA 500 of the cat group), and TIA (r>0.649, p<0.001, and r>0.791, p<0.001, respectively). In addition, in the cat and combi groups, there were significant correlations between the preoperative ACD and LT, preoperative LV and LT, and preoperative ACD and LV (r=-0.708, p<0.001; r=0.673, p<0.001; r=-0.808, p<0.001 in the cat group, r=-0.808, p<0.001; r=0.713, p<0.001; r=-0.799, p<0.001 in combi group, respectively; Table 4).

Multiple regression analysis showed that preoperative ACD was the most relevant factor determining preoperative AOD 750, TISA 750, TIA 750 in the cat and combi groups (standardized coefficient β=0.863, p<0.001; β=1.009, p<0.001; β=1.094, p<0.001 for the cat group; β=0.865, p<0.001; β=0.836, p<0.001; β=0.570, p=0.002 for the combi group, respectively) with LT being an additional relevant factor in the cat group (β=0.505, p=0.004; β=0.455, p=0.021; β=0.638, p=0.001, respectively). Regarding postoperative AOD 750, TISA 750, and TIA 750, postoperative ACD was identified as a relevant factor only in the combi group (β=0.647, p=0.002; β=0.436, p=0.040; and β=0.685, p=0.002, respectively). Associations between the changes in AOD, TISA, and
TIA and changes in ACD and LV were not significant.

DISCUSSION

IOP reduction after cataract surgery, including extracapsular cataract extraction and phacoemulsification, has been demonstrated in various articles.[15-17] However, few studies have been conducted on IOP changes after a combined operation, and controversies regarding IOP changes after vitrectomy had existed.[18,19] Masis Solano and Lin reviewed the pathophysiological mechanisms of IOP reduction after cataract extraction using molecular theory, which demonstrates the action of cytokines or prostaglandins on the trabecular meshwork, physiological theory by the position changes of the ciliary body, and biomechanical theory according to changes in the anterior segment anatomy.[3] Recently, with the development of AS-OCT, interest in anterior segment image analysis has increased, and the number of studies analyzing changes in the anterior segment anatomy after cataract surgery using various parameters with AS-OCT has increased. Only a few studies have investigated the effects of vitrectomy or phacovitrectomy on anterior segment parameters using AS-OCT.[8] Thus, we aimed to analyze and compare changes in the anterior segment anatomy and IOP not only after simple cataract surgery but also after vitrectomy or combined surgery and to determine the relationship between the anterior segment parameters and IOP.

In the present study, changes in the IOP and anterior chamber parameters associated with cataract surgery, simple vitrectomy, and combined surgery were investigated. Postoperative IOP decreased in the cat and combi groups but not in the vit group. After surgery, CCT and ACD increased, and LV moved backward in the cat and combi groups. The anterior chamber angle-associated parameters, including AOD, TISA, and TIA at 500 and 750 μm in the cat and combi groups increased after surgery, but there was no significant change in vitrectomy group. When preoperative measurements of the anterior chamber angle-associated parameters and ACD were smaller, preoperative IOP was higher was greater in the cat and combi groups. IOP changes was negatively related with preoperative ACD in the cat and combi groups. Postoperative IOP was not correlated with postoperative anterior chamber angle-associated parameters. In the regression analysis, preoperative ACD was found to be related to the preoperative anterior chamber angle-associated parameters in both groups. There were no common factors related to the postoperative parameters or changes in the parameters in both groups. In the vitrectomy group, no significant changes in the anterior segment measurements were observed, except for a relatively small changes in ACD compared with the other groups.
Yang et al. and Hirasawa et al. reported that IOP decreased from 13.5 ± 2.9 mmHg to 11.9 ± 2.8 mmHg and from 16.5 ± 4.0 mmHg to 12.6 ± 2.8 mmHg, respectively, after cataract surgery.\(^{[19,20]}\) In our study, a similar significant decrease in IOP was observed in the cat group after surgery. In terms of vitrectomy, Wu et al. reported that the rate of eyes with elevated IOP after surgery was 19.2%, which was significantly higher than 4.5% in the contralateral eye, while the mean IOP decreased from 15 ± 3.5 mmHg to 14.7 ± 2.8 mmHg.\(^{[7]}\) In a study by Cabuk et al., IOP was found to be consistently higher than the baseline value during the 12 months of follow-up after vitrectomy or phacovitrectomy.\(^{[21]}\) In the research of Mi and Thompson, the mean IOP showed no significant change after vitrectomy regardless of lens status.\(^{[22]}\) Yamamoto et al. concluded that at 12 months after vitrectomy or phacovitrectomy, changes in IOP were not significant in ERM and MH, but IOP significantly increased in rhegmatogenous retinal detachment (RRD).\(^{[23]}\) Unlike other studies that did not consider lens status, ocular disease affecting IOP, or combining cataract surgery, our study only enrolled pseudophakic patients with ERM and MH in the vit group and the effect of vitrectomy on the IOP, which showed no significant changes, could be more accurately confirmed. Regarding the combined surgery, Ki-I et al. reported a decrease in IOP at three months, which then returned to baseline at 12 months, and the result of Byun et al. showed no significant IOP changes until 12 months after surgery.\(^{[18,24]}\) In our study, the IOP continuously decreased for six months, which is different from the findings of the above studies. In the report by Byun et al., diseases with a risk of glaucoma or the tendency of postoperative IOP increase was included, and it is presumed that these factors affected the results.\(^{[24]}\) Compared to the results of Ki-I et al., IOP did not show a tendency of rebounding to the baseline values after 3 month in our study. Because there was a decrease in IOP after cataract surgery and no significant change in IOP after vitrectomy, the decrease in IOP after combined surgery was considered a reasonable result.

Regarding changes in the anterior segment parameters after cataract surgery, Yang et al. reported that ACD increased from 2.60 ± 0.35 mm to 3.43 ± 0.35 mm, and AOD 500 increased from 0.26 ± 0.03 to 0.44 ± 0.04 after cataract surgery.\(^{[19]}\) Kim et al. reported similar significant postoperative increases in TIA, AOD, and TISA.\(^{[25]}\) These results are consistent with the current study. Regarding the vitrectomy, in a study by Khodabande et al., there were no changes in ACD, AOD, TISA, or TIA after vitrectomy.\(^{[8]}\) However, in a study by Toklu et al., postoperative ACD was reduced in cases of complete vitrectomy with scleral indentation.\(^{[26]}\) They suggest that the presence of the anterior vitreous can affect ACD after vitrectomy. Unlike previous studies, the results of our study showed an increase in ACD, and to confirm these differences, it is necessary to check the additional confirmation of the relationship between the extent of anterior vitrectomy and ACD. For the combined surgery, no studies have been reported on anterior segment parameters using AS-OCT, except for ACD. According to the
report of Seo et al. there were larger increase of ACD in the combined surgery group than that in cataract surgery group and decrease of ACD in vitrectomy group. Those results were different from our result which showed no difference in ACD between the cataract and combined surgery groups and increase of ACD in vitrectomy group. The difference between two studies in the vitrectomy group is that our study targeted pseudophakic eyes, but the study of Seo et al. targeted phakic eyes in the vitrectomy group, so it is thought that the presence of the crystalline lens or cataract changes may have contributed to the difference. The exact cause of the difference in the results of the two studies regarding the additional ACD increase in the combined operation is unknown, but it may be due to differences in the extent of vitrectomy resection or used the intraocular lens.

Regarding the anterior segment parameters affecting IOP changes, Yang et al. concluded that preoperative ACD, AOD, and changes in ACD and AOD were significant factors, and Perez et al. concluded that ACD and AOD 750 were related to IOP. Unlike the study by Yang et al., changes in IOP in the result of our study and Perez et al. were not associated with changes of anterior chamber parameters. This difference is thought to be due to the relatively small number of eyes included or changes in correlation between IOP and the anterior segment parameters after surgery. In our result, since IOP had no correlation with AOD, TISA, and TIA after surgery, changes in IOP were not correlated with changes of AOD, TISA and TIA. These changes may occur because the effect of lens vaulting on preoperative IOP decreased after surgery and the influence of angle-related effects was reduced.

Increase of central corneal thickness after cataract surgery was assumed to be due to corneal edema and surgically induced astigmatism. It is reported that the effect of corneal edema mostly improves in about 1 week and becomes similar to the preoperative level in approximately 3-12 months. The effects of surgically induced astigmatism are reported to improve within 2 months. In this study, the CCT improved close to baseline at 6 months, but the remaining small increase in thickness may be due to differences in surgical methods using superior cornea incision, relatively higher age than previous studies, differences in underlying diseases, and whether or not vitrectomy was used. Since IOP measurement is affected by CCT, IOP may be measured higher as corneal edema increases. The increase of CCT at 1 month was approximately 20 μm, which may lead to underestimation of the IOP reduction. However, because the CCT difference between baseline and 6 months was less than 10 μm, it is thought that there was no significant effect on the IOP measurement at 6 months.

Our study identified factors influencing preoperative AOD, TISA, and TIA as LV and ACD in the cat group and LT and ACD in the combi group. Preoperative ACD was identified as the most important factor in multiple regression analysis. Since LT, LV, and ACD are factors related to each other, not only in our study but also in many
other articles, it is presumed that change in IOP after surgery in the cat and combi groups are related to the anterior angle changes identified by AOD, TISA, and TIA according to changes in anterior segment shape and ACD due to crystalline lens removal.

This study had several limitations. First, the number of eyes included in the study was small, particularly in the vit group. However, the data in the vit group were relatively constant and normally distributed in the normality test. Second, we did not analyze the axial length to determine the relationship between the overall eye shape and ACD. Third, we used a non-contact tonometer to measure IOP, which can be relatively inaccurate. To compensate for this, we obtained at least three measurements and rechecked them with a rebound-type tonometer to determine whether they differed from the previous measurement. Fourth, the total follow-up period for each participant was relatively short. Fifth, our vitrectomy group consisted with pseudophakic eyes and it did not reflect the results of vitrectomy for phakic eyes.

In conclusion, this study confirmed that decreased IOP and increased AOD, TISA, and TIA after cataract and combined surgery using AS-OCT. In addition, the preoperative AOD, TISA, and TIA were associated with changes in the IOP. The preoperative ACD was most related to changes in the anterior chamber angle after cataract and combined surgery. After vitrectomy surgery, there was a relatively small change in the ACD compared with that in the other surgeries and no significant change in the anterior segment measurements was observed.

Considering the correlation between lens vaulting and anterior chamber angle-related parameters, postoperative IOP changes are thought to be due to changes in the anterior angle according to crystalline lens removal.

**Data availability:** The data generated or analyzed during this study are available from the corresponding authors upon reasonable request.

**Conflict of interest:** The authors have no conflicts of interest to declare.

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**Author contributions:** Sangyoon Kim and Seung Min Lee contributed to the conception and design of this study. Data collection and analysis were performed by Sangyoon Kim and Seung Min Lee. The first draft of the manuscript was written by Sangyoon Kim and Seung Min Lee. Su Hwan Park reviewed the draft and revised the manuscript. All authors commented on the previous versions of the manuscript critically. All authors have read
and approved the final manuscript.

**Acknowledgement:** None
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References


Figure 1. Representative case showing anterior segment parameters measured by anterior segment optical coherence tomography using manufacturer-provided software. Central corneal thickness (CCT), anterior chamber depth (ACD), lens vault (LV) and angle-to-angle distance (ATA) are displayed on the cross-sectional image of anterior segment (lower panel). Angle opening distance (AOD), trabecular–iris space area (TISA), and trabecular-iris angle (TIA) are presented on the left, middle, right side of the upper panel, respectively. AOD, TISA, and TIA are measured at 500 μm and 750 μm from the scleral spur (SS). AOD is the length of the line perpendicular to the cornea from the cornea to the iris. TISA is marked as red trapezoidal area between the AOD line and a perpendicular line at the scleral spur. For TIA, the angle is measured from the angle recess (AR), which is the apex of a triangle with the AOD line as its base.
Figure 2. Trends in intraocular pressure (IOP), central corneal thickness (CCT), and anterior chamber depth (ACD) at baseline and one and six months after surgery. (A) In the cataract (cat) and combined (Comb) groups, IOP significantly decreased one and six months postoperatively compared to baseline. (B) Similarly, the CCT significantly increased in these two groups while decreasing from postoperative one month to six months. (C) In the case of ACD, all three groups showed a significant increase from baseline to six months postoperatively, while only the cat and combi groups showed a significant increase from baseline to one month postoperatively.
Figure 3. Trends in the angle opening distance at 750 mm (AOD 750), trabecular-iris space area at 750 mm (TISA 750), and the trabecular-iris angle at 750 mm (TIA 750) at baseline and one and six months after surgery. AOD 750 (A), TISA 750 (B), and TIA 750 (C) showed similar changes from baseline to six months postoperatively, showing a significant increase from baseline to one month postoperatively and baseline to six months postoperatively in the cat and combi groups.
Table 1. Baseline characteristics

<table>
<thead>
<tr>
<th></th>
<th>Cataract group (N=41)</th>
<th>Vitrectomy group* (N=15)</th>
<th>Combined group (N=40)</th>
<th>p value*</th>
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<tr>
<td>Sex (M:F)</td>
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<td>10 : 5</td>
<td>26 : 14</td>
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<td>Age (year)</td>
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<td>Laterality</td>
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<td></td>
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<td>(right eye : left eye)</td>
<td>23 : 18</td>
<td>7 : 8</td>
<td>23 : 17</td>
<td></td>
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<td>BCVA (LogMAR)</td>
<td>0.70 ± 0.53</td>
<td>0.68 ± 0.43</td>
<td>0.61 ± 0.47</td>
<td>0.726</td>
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<td>Refractive error (Sph. equivalent)</td>
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<td>Axial length (mm)</td>
<td>23.8 ± 1.1</td>
<td>23.4 ± 1.1</td>
<td>23.5 ± 1.02</td>
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<td>IOP (mmHg)</td>
<td>15.8 ± 1.8</td>
<td>15.3 ± 2.6</td>
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<td>Lens thickness (mm)</td>
<td>4.6 ± 0.3</td>
<td>4.6 ± 0.3</td>
<td>0.871</td>
<td></td>
</tr>
</tbody>
</table>

BCVA = Best-corrected visual acuity; IOP = Intraocular pressure; logMAR = Logarithm of the minimum angle of resolution.

* = Vitrectomy group consisted of pseudophakic eyes.

# = p value by analysis using analysis of variance, independent t-test, or Chi-square test.

& = post-hoc Scheffé test: the cat group versus the combi group, p<0.019
Table 2. IOP and Anterior chamber parameters changes

<table>
<thead>
<tr>
<th></th>
<th>Cataract group (C., N=41)</th>
<th>Vitrectomy group (V., N=15)</th>
<th>Combined group (Co., N=40)</th>
<th>Post hoc test(^a) (p value)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>C vs. V/ C vs. Co/ V vs. Co</td>
<td></td>
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<tr>
<td><strong>IOP (㎜ Hg)</strong></td>
<td>pre 15.8 ± 1.8</td>
<td>15.4 ± 2.6</td>
<td>15.8 ± 3.3</td>
<td>0.879/0.818/0.969/0.904</td>
</tr>
<tr>
<td></td>
<td>6 m 13.4 ± 2.0(^†)</td>
<td>14.3 ± 2.6</td>
<td>14.2 ± 2.5(^†)</td>
<td>0.267/0.890/0.943/0.974</td>
</tr>
<tr>
<td><strong>CCT (㎛)</strong></td>
<td>pre 526 ± 27</td>
<td>534 ± 22</td>
<td>540 ± 36</td>
<td>0.147/0.770/0.147/0.778</td>
</tr>
<tr>
<td></td>
<td>6 m 532 ± 31(^†)</td>
<td>536 ± 23</td>
<td>548 ± 36(^†)</td>
<td>0.090/0.932/0.097/0.516</td>
</tr>
<tr>
<td><strong>ACD (㎜)</strong></td>
<td>pre 2.659 ± 0.376</td>
<td>3.920 ± 0.694</td>
<td>2.606 ± 0.365</td>
<td>0.000/0.000/0.864/0.000</td>
</tr>
<tr>
<td></td>
<td>6 m 4.378 ± 0.359(^†)</td>
<td>3.958 ± 0.677(^†)</td>
<td>4.240 ± 0.315(^†)</td>
<td>0.006/0.006/0.380/0.049</td>
</tr>
<tr>
<td><strong>LV</strong></td>
<td>pre -1.281 ± 0.245(^†)</td>
<td>-0.976 ± 0.268</td>
<td>-1.184 ± 0.175(^†)</td>
<td>0.000/0.001/0.254/0.032</td>
</tr>
<tr>
<td></td>
<td>6 m -1.281 ± 0.245(^†)</td>
<td>-0.976 ± 0.268</td>
<td>-1.184 ± 0.175(^†)</td>
<td>0.000/0.001/0.254/0.032</td>
</tr>
<tr>
<td><strong>AOD500</strong></td>
<td>pre 0.323 ± 0.126</td>
<td>0.496 ± 0.226</td>
<td>0.384 ± 0.167</td>
<td>0.003/0.004/0.252/0.050</td>
</tr>
<tr>
<td></td>
<td>6 m 0.482 ± 0.108(^†)</td>
<td>0.501 ± 0.216</td>
<td>0.542 ± 0.132(^†)</td>
<td>0.175/0.912/0.181/0.657</td>
</tr>
<tr>
<td><strong>AOD750</strong></td>
<td>pre 0.465 ± 0.186</td>
<td>0.691 ± 0.322</td>
<td>0.558 ± 0.253</td>
<td>0.010/0.012/0.230/0.208</td>
</tr>
<tr>
<td></td>
<td>6 m 0.720 ± 0.149(^†)</td>
<td>0.720 ± 0.325</td>
<td>0.770 ± 0.170(^†)</td>
<td>0.486/1.000/0.531/0.726</td>
</tr>
<tr>
<td><strong>TISA500</strong></td>
<td>pre 0.130 ± 0.076</td>
<td>0.183 ± 0.073</td>
<td>0.141 ± 0.056</td>
<td>0.047/0.049/0.794/0.141</td>
</tr>
<tr>
<td></td>
<td>6 m 0.164 ± 0.038(^†)</td>
<td>0.178 ± 0.066</td>
<td>0.190 ± 0.052(^†)</td>
<td>0.073/0.651/0.073/0.758</td>
</tr>
<tr>
<td><strong>TISA750</strong></td>
<td>pre 0.219 ± 0.077</td>
<td>0.334 ± 0.140</td>
<td>0.259 ± 0.107</td>
<td>0.002/0.002/0.214/0.048</td>
</tr>
<tr>
<td></td>
<td>6 m 0.315 ± 0.067(^†)</td>
<td>0.334 ± 0.132</td>
<td>0.357 ± 0.087(^†)</td>
<td>0.125/0.810/0.125/0.705</td>
</tr>
<tr>
<td><strong>TIA500</strong></td>
<td>pre 33.4 ± 10.3</td>
<td>44.8 ± 12.4</td>
<td>36.9 ± 12.8</td>
<td>0.013/0.013/0.509/0.103</td>
</tr>
<tr>
<td></td>
<td>6 m 47.3 ± 7.7(^†)</td>
<td>46.3 ± 12.6</td>
<td>49.0 ± 7.9(^†)</td>
<td>0.460/0.986/0.550/0.631</td>
</tr>
<tr>
<td><strong>TIA750</strong></td>
<td>pre 32.3 ± 10.25</td>
<td>42.8 ± 12.3</td>
<td>36.0 ± 12.7</td>
<td>0.017/0.018/0.383/0.177</td>
</tr>
<tr>
<td></td>
<td>6 m 46.2 ± 5.8(^†)</td>
<td>44.4 ± 12.1</td>
<td>47.9 ± 6.9(^†)</td>
<td>0.322/0.762/0.625/0.360</td>
</tr>
</tbody>
</table>

ACD = Anterior chamber depth; AOD = Angle opening distance; CCT = central corneal thickness; IOP = Intraocular pressure; LV = Lens vault; TISA = Trabecular-iris space area; TIA = Trabecular-iris angle; vs. = versus.

\(^*\) = p value, comparison among 3 groups using the ANOVA.

\(^\#\) = Scheffé test

\(^†\) = Statistically significant difference between preoperation and 6 month follow up (p < 0.05).
Table 3. Correlation analysis between the difference in IOP (from baseline to six months after surgery) and preoperative anterior segment parameters

<table>
<thead>
<tr>
<th>ΔIOP</th>
<th>Cataract group</th>
<th>Vitrectomy group</th>
<th>Combined group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p value *</td>
<td>r</td>
</tr>
<tr>
<td>Preoperative AOD500</td>
<td>0.410</td>
<td>0.012</td>
<td>0.425</td>
</tr>
<tr>
<td>Preoperative AOD750</td>
<td>0.442</td>
<td>0.006</td>
<td>0.326</td>
</tr>
<tr>
<td>Preoperative TISA500</td>
<td>0.170</td>
<td>0.315</td>
<td>0.438</td>
</tr>
<tr>
<td>Preoperative TISA750</td>
<td>0.446</td>
<td>0.006</td>
<td>0.365</td>
</tr>
<tr>
<td>Preoperative TIA500</td>
<td>0.342</td>
<td>0.038</td>
<td>0.340</td>
</tr>
<tr>
<td>Preoperative TIA750</td>
<td>0.390</td>
<td>0.017</td>
<td>0.427</td>
</tr>
</tbody>
</table>

ΔIOP = (baseline intraocular pressure) – (intraocular pressure at six months after surgery); AOD = Angle opening distance; TISA = Trabecular-iris space area; TIA = Trabecular-iris angle.

r = correlation coefficient by Pearson’s correlation analysis

* = p value of correlation by Pearson’s correlation analysis
Table 4. Correlation analysis between the preoperative ACD, LT, and LV in the cat and combi groups

<table>
<thead>
<tr>
<th></th>
<th>Preoperative LT</th>
<th>Preoperative LV</th>
<th>Preoperative ACD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cataract group</td>
<td>Combined group</td>
<td>Cataract group</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>p value *</td>
<td>r</td>
</tr>
<tr>
<td>Preoperative LT</td>
<td>0.673</td>
<td>0.000</td>
<td>0.713</td>
</tr>
<tr>
<td>Preoperative LV</td>
<td>0.673</td>
<td>0.000</td>
<td>0.713</td>
</tr>
<tr>
<td>Preoperative ACD</td>
<td>-0.708</td>
<td>0.000</td>
<td>-0.808</td>
</tr>
</tbody>
</table>

ACD = Anterior chamber depth; LT = Lens thickness; LV = Lens vault; AOD = Angle opening distance; TISA = Trabecular-iris space area; TIA = Trabecular-iris angle.

r = correlation coefficient by Pearson’s correlation analysis

* = p value of correlation by Pearson’s correlation analysis