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Anterior segment morphometry and intraocular pressure change after uneventful phacoemulsification

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Aim: To evaluate the changes in anterior segment morphometry and intraocular pressure (IOP) with 3D rotating Scheimpflug camera-topography system after uneventful phacoemulsification.

Materials and methods: In 56 eyes of 54 patients, anterior chamber depth (ACD), anterior chamber volume (ACV), anterior chamber angle (ACA), and central corneal thickness (CCT) were measured with the Sirius 3D Rotating Scheimpflug camera-topography system preoperatively and 1 month after surgery. IOP was measured with applanation tonometer. The preoperative and postoperative results were compared.

Results: Preoperative and postoperative anterior segment parameters were as follows: ACD 2.7 ± 0.4 and 3.5 ± 0.3 mm, ACV 143.6 ± 48.8 and 192.4 ± 59.5 mm^3, nasal ACA 42.3 ± 8.4° and 53.0 ± 4.5°, temporal ACA 36.9 ± 11.9° and 45.8 ± 13.2° ($P < 0.001$). CCT, iris diameter, and pupil diameter changes were not statistically significant ($P > 0.05$). Mean axial length (AL) was 23.4 ± 0.8 mm. The IOP and corrected IOP were 14.6 ± 3.5 and 14.5 ± 3.9 preoperatively and 10.4 ± 2.4 and 10.0 ± 3.3 mmHg postoperatively ($P < 0.001$). There was not a correlation between AL and IOP, ACD, ACV, or ACA, and no correlation was found between IOP change and ACD, ACV, or ACA ($P > 0.05$).

Conclusion: Measurements confirm that after uneventful phacoemulsification, IOP decreases while ACD, ACV, and ACA increase. Preoperative AL and IOP changes did not correlate with ACD, ACV, and ACA.

Key words: Phacoemulsification, anterior segment, intraocular pressure, Sirius, Scheimpflug camera

1. Introduction

Anterior segment morphometry and intraocular pressure (IOP) changes after phacoemulsification and intraocular lens implantation are well documented so far (1–3). Different devices are used in anterior chamber imaging. One of these methods is ultrasound biomicroscopy (UBM), which provides high-resolution anterior segment imaging even with opaque media (4–6). However, UBM measurements may be uncomfortable for most patients and the experience of the observer may affect the results. There are faster, noncontact, noninvasive, and comfortable new devices and methods, which have higher reliability and repeatability for anterior segment measurements, such as anterior segment optical coherence tomography (AS-OCT) (7–9), the Pentacam (10–12), and the Sirius (13,14) rotating Scheimpflug camera.

In this study, we aimed to investigate the change in IOP and anterior chamber morphometry after uneventful phacoemulsification using Sirius 3D rotating Scheimpflug camera-topography system.

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2. Materials and methods

Fifty-six eyes of 54 patients who underwent uneventful phacoemulsification surgery were included in this prospective study. Exclusion criteria were accompanying cornea and anterior segment pathology, pseudoexfoliation syndrome, glaucoma, angle-closure history, previous ocular surgery, and trauma. The study performed complied with the tenets of the Declaration of Helsinki and informed consent was received from each patient.

All patients underwent detailed ophthalmologic examination (best corrected visual acuity, biomicroscopy, fundus examination, IOP measurement with Goldmann applanation tonometer, and axial length measurement) before and 1 month after the surgery. Anterior chamber depth (ACD), anterior chamber volume (ACV), anterior chamber angle (ACA) in nasal and temporal quadrants, central corneal thickness (CCT), and iris and pupil diameters were measured using a Sirius 3D Rotating Scheimpflug Camera-Topography System (Costruzione Strumenti Oftalmici, Florence, Italy). IOP was measured with Goldmann applanation tonometer and corrected IOP was automatically calculated by Ehlers' formula with a Sirius device. Ehlers' formula [corrected IOP = uncorrected IOP – (CCT – 520) × (5 / 70)] corrects IOP by using CCT.

All patients underwent torsional phacoemulsification with 2.2-mm clear corneal incisions and coaxial microincisional phaco surgery by the same surgeon (TT). An Infiniti unit (Alcon Laboratories), OZil Torsional Handpiece, and mini-flared 30° Kelman tip with ultrasleeve were used in surgery. Acriva^{UD} 613 (VSY Biotechnology, İstanbul, Turkey) intraocular lenses, which are foldable, aspheric, and have acrylic with hydrophobic surface optics, were implanted in the bag and incisions were closed with stromal hydration. Standard, topical antibiotic and steroid drops were used in all eyes postoperatively.

A repeatability test was performed for the Sirius 3D Rotating Scheimpflug Camera-Topography System based on Bland and Altman's suggestions (15). A healthy patient was used for this, 10 sequential measurements were performed, and ACD measurements were used for the performing test. The coefficient of repeatability was 0.041 µm for the ACD.

Statistical analysis was performed with SPSS 16.0 for Windows (SPSS Inc.). The paired t-test was used to compare variables and Pearson's correlation analysis was used to evaluate the relationships among different variables. P < 0.05 was considered statistically significant.

3. Results

Mean age was 66.0 ± 10.1 years. Out of the 54 patients, 30 (55.5%) were women and 24 (44.4%) were men. Preoperative and postoperative anterior chamber measurements were as follows: ACD 2.7 ± 0.4 and 3.5 ± 0.3 mm (P = 0.001), ACV 143.6 ± 48.8 and 192.4 ± 59.5 mm^3 (P = 0.001), ACA in nasal quadrant 42.3 ± 8.4° and 53.0 ± 4.5° (P = 0.001), and ACA in temporal quadrant 36.9 ± 11.9° and 45.8 ± 13.2° (P = 0.001) (Table 1).

Preoperative and postoperative IOP was 14.6 ± 3.5 mmHg and 10.4 ± 2.4 mmHg, respectively (P = 0.001) (Table 2). Corrected preoperative IOP was 14.5 ± 3.9 and postoperative IOP was 10.0 ± 3.3 mmHg (P = 0.001). CCT (545.7 ± 36.2 and 550.5 ± 40.2 µm, P = 0.108), iris diameter (11.8 ± 0.3 and 11.7 ± 0.4 mm, P = 0.119), and pupil diameter (3.4 ± 1.2 and 3.6 ± 1.7 mm, P = 0.324) measurements before and after surgery were not statistically significantly different (Table 2).

Mean axial length (AL) was 23.4 ± 0.8 (21.6–25.2) mm, and AL did not correlate with IOP, ACD, ACV, or ACA change (P > 0.05). In addition, no correlation was found between IOP change and ACD, ACV, or ACA change (P > 0.05).

Table 1. Anterior segment morphometry change after phacoemulsification.

	Preoperative mean ± SD	Postoperative mean ± SD	P-value
Anterior chamber depth (mm)	2.7 ± 0.4	3.5 ± 0.3	0.001
Anterior chamber volume (mm^3)	143.6 ± 48.8	192.4 ± 59.5	0.001
Anterior chamber angle (nasal, degrees)	42.3 ± 8.4	53.0 ± 4.5	0.001
Anterior chamber angle (temporal, degrees)	36.9 ± 11.9	45.8 ± 13.2	0.001

Table 2. Preoperative and postoperative intraocular pressure and anterior chamber measurements.

	Preoperative mean ± SD	Postoperative mean ± SD	P-value
İntraocular pressure (mmHg)	14.6 ± 3.5	10.4 ± 2.4	0.001
Corrected* intraocular pressure (mmHg)	14.5 ± 3.9	10.0 ± 3.3	0.001
Pupil diameter (mm)	3.4 ± 1.2	3.6 ± 1.7	0.324
Iris diameter (mm)	11.8 ± 0.3	11.7 ± 0.4	0.119
Central corneal thickness (µm)	545.7 ± 36.2	550.5 ± 40.2	0.108

*Corrected IOP: Ehlers' formula = corrected IOP = uncorrected IOP – (CCT – 520) × (5 / 70).

4. Discussion

Scheimpflug cameras provide focused images from the anterior corneal surface to the posterior lens and transform them into a 3D model with their rotation capability (16). The first Scheimpflug camera in ophthalmology practice was the Pentacam (Oculus Optikgeräte GmbH). After Pentacam, Galilei (Ziemer Group) introduced a combination Scheimpflug camera and Placido-disk topography system. Recently 2 other devices containing a Scheimpflug camera and a Placido-disk topography system, the Sirius (Costruzione Strumenti Oftalmici) and the TMS-5 (Tomey Corp.), were developed.

The Sirius acquires 25 Scheimpflug images and a Placido-disk image with 22 rings in a scanning process. Anterior surface data are calculated by merging Scheimpflug and Placido-disk images. Data for the internal structures (posterior cornea surface, anterior lens surface, and iris) are derived only from the Scheimpflug camera.

Savini et al. (13) compared measurements from a Scheimpflug camera (Pentacam), Scheimpflug camera and Placido-disk (Sirius-TMS-5), and Placido-disk topography (Keratron) and found that in many cases measurements cannot be considered interchangeable. For this, all devices must be investigated in many aspects. In another study, Savini et al. (14) found that repeatability with Sirius was similar to that reported for Pentacam and Galilei. In studies by Nasser et al. (17) and Chen et al. (18), the Sirius device showed good to excellent repeatability for all measured parameters. Like Savini et al. (13), Nasser et al. (17) also found that Pentacam and Sirius should not be used interchangeably.

To our knowledge, this is the first study featuring anterior segment morphometry after uneventful phacoemulsification by using the Sirius device (Costruzione Strumenti Oftalmici).

After phacoemulsification, mean ACD, mean ACV, and mean ACA in the nasal quadrant and temporal quadrant increased 1.29, 1.33, 1.23, and 1.25 times, respectively. Our results showed that the more shallow anterior chambers preoperatively became the deeper ones postoperatively. Pereira and Cronemberger (6) found an increase in ACD of 1.31 and ACA in nasal quadrant 1.53, in temporal quadrant 1.26, in superior quadrant 1.36, and in inferior quadrant 1.52 times in a study with UBM. Using Pentacam, Uçakhan et al. (11) reported that ACD, ACV, and ACA increased respectively 1.34, 1.22, and 1.24 times 3 months after phacoemulsification. In the former study (6), it was found that there was approximately a 10° angular backward shift of iris after crystalline lens removal and the relief of relative pupillary block in patients with a shallow anterior chamber.

IOP decrease after phacoemulsification has been shown in many studies, both in normotensive and open-angle glaucoma groups (1) and in glaucoma patients (19). In our study, we also calculated corrected IOP using Ehlers' formula. Corrected IOP measurements were similar to uncorrected IOP. In the latter study (19), it was concluded that ACA widening was the cause of the decrease in IOP. Angle-closure glaucoma phacoemulsification may provide a permanent fall in IOP, because the main problem is the anterior segment and angle abnormality. After phacoemulsification, the ACD and ACA values may also increase. Phacoemulsification can be the first choice of treatment in patients who have cataracts with shallow-angle or angle-closure glaucoma. Because the glaucoma mechanism is different in open-angle glaucoma, postoperative IOP decrease may be transient in those patients.

In our study, IOP decrease was not found to correlate with ACD, ACV, and ACA change. Altan et al. (1) and Kashiwagi et al. (20) also did not find a correlation between these parameters. Although the main cause of IOP decrease after phacoemulsification may not be clarified, probable mechanisms mentioned in many studies include increased uveoscleral outflow, decreased resistance to aqueous humor outflow, and hyposecretion of aqueous humor (21,22).

Many devices are used to measure CCT, but ultrasound pachymetry is still the gold standard. Some studies showed that Pentacam measurements were similar to but thinner than ultrasound pachymetry (23,24). There is no comparative study between Sirius/TMS-5 measurements and ultrasound pachymetry. CCT was found to be 534 µm in the study by Doganay (10) using Pentacam. In our study, we found a CCT of 545 µm with Sirius. Studies comparing these devices are needed to find out which of these measurements is closer to the measurements of ultrasound pachymetry.

Pupil size is adjusted by the iris according to how much light is coming into the eye. Important functions of the pupil are prohibition of glare, a role in accommodation, binocular single vision, and visual acuity. Pupil size is important particularly in patients with implanted multifocal intraocular lens, and preoperative pupil size can be predictable for postoperative pupil size. Pupil size may be 8 mm in dim light and 1.5 mm in bright conditions. We found the pupil size preoperatively to be 3.4 mm, and there was not a statistically significant difference between preoperative and postoperative values. In the study of Doganay et al. (10) with Pentacam, pupil size was 2.6 mm and no significant change was determined after phacoemulsification. Hayashi et al. (25) demonstrated a significant fall in pupil size on postoperative day 3, and 1 month after surgery pupil size was similar to preoperative values. In our study, horizontal iris diameter was found proportional to pupil size and preoperative and postoperative measurements were similar.

Axial length measurements were found to correlate with anterior segment parameters in some studies (8,26). Kim et al. (8) found that in patients with AL < 23 mm, ACD and angle parameters were smaller and this statistical discrepancy also continued after surgery. Hosny et al. (26) concluded that AL correlated with ACD. Although we did not classify the patients according to AL measurements, we observed that smaller anterior segment parameters were seen with smaller AL values. No statistically significant correlation was found between AL and IOP, ACD, ACV, or ACA changes.

In conclusion, we demonstrated that anterior segment morphometry changed after phacoemulsification using a Sirius 3D rotating Scheimpflug camera Placido-disk system. IOP and corrected IOP decreased after phacoemulsification, and there was no correlation between IOP change and anterior segment morphometric changes. We also found that there was no correlation between AL and anterior segment morphometric changes.

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