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CLINICAL STUDY

The quantitative assessment of alterations in lens transparency after transconjunctival 27-gauge microincision vitrectomy surgery

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Abstract

Purpose **To evaluate the baseline and post-vitrectomy lens densitometry values by a Scheimpflug camera in eyes with epiretinal membrane that were treated with 27-G microincision vitrectomy surgery (MIVS) without tamponade and to compare the results with those in fellow healthy eyes.**

Patients and methods **Prospective case series. The lens densitometry measurements of 24 patients, who underwent 27-G MIVS without any tamponade for the treatment of epiretinal membrane, were taken preoperatively and on the first week, first month, and third month postoperatively with Pentacam HR-Scheimpflug imaging system.**

Results **The mean lens densitometry values at Zone 1 and average lens densitometry values significantly increased in the study eyes on the first month when compared with the preoperative values ($P=0.011$, $P=0.033$, respectively). Additionally, there were statistically significant differences regarding the mean lens densitometry values of Zone 1 and Zone 2, and also average lens densitometry values between the preoperative and third month postoperative values ($P=0.003$, $P=0.021$, $P=0.009$, respectively). However, the densitometry values of fellow eyes were similar at preoperatively and all the postoperative follow-up periods ($P>0.05$ for all).**

Conclusions **This study suggests that 27-G MIVS might cause post-surgical lens density changes even in early postoperative months and vitreous may play an important role in protecting the transparency of the lens.**

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Introduction

In the present day, microincision vitrectomy surgery (MIVS) with 23-gauge (G) and 25-G instrumentation is mostly used instead of traditional 20-G pars plana vitrectomy (PPV). Additionally, in 2010, Oshima *et al*[1] firstly described the initial feasibility and safety of a novel 27-G instrument system, reporting excellent visual and anatomic outcomes. It has been well documented in the literature that utilization of smaller-diameter instruments with self-sealing, transconjunctival scleral wounds provide some advantages such as decreased postoperative pain and inflammation, decreased induced astigmatism, and improved patient comfort.[2–5] On the other hand, despite these improvements, some complications are still available following PPV in which cataract development or acceleration is one of the most common.

Vitrectomy-related cataractogenesis is commonly reported following 20-G PPV with an incidence rate varying from 12.5 to 80%.[6–8] It was reported that 23-G and 25-G MIVS systems are potentially less risky than standard 20-G PPV system since the reduced balanced solution consumption, lower intravitreal fluid flow, decreased surgical time, and ocular manipulations.[9,10] The cataract rates in most of these aforementioned studies rely on the data of clinical examinations, not quantitative analyses.

A quantitative analysis of lens transparency is crucial to objectively determinate the effect of risk factors for cataractogenesis and to document the progression of cataract level during the follow-up period. The optimal system to determinate the lens transparency must be objective and reproducible. Recent

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developments of the Scheimpflug topography systems have enabled quantitative measurements of the lens transparency. The Pentacam HR (Oculus, Wetzlar, Germany) that uses a rotating Scheimpflug camera to image the anterior ocular segment from the anterior corneal surface to the posterior lens surface provides anterior and posterior corneal topography and three-dimension anterior chamber analysis.[11–13] It can also provide precise and reproducible data related to lens densitometry, that is a quantitative and objective method to assess the lens transparency.[14,15] The Pentacam HR reveals a three-dimension image of the crystalline lens and a measurement of the lens density in the chosen area, that ranges from 0 (no lens clouding-completely clear) to 100 (completely opaque). This system also has high intra-observer and inter-observer repeatability rates in eyes with and without cataract.[15–17]

In this study, we aimed to evaluate the baseline and post-vitrectomy lens densitometry values in eyes with epiretinal membrane that were treated with 27-G MIVS without tamponade, and to compare the results with those in fellow healthy eyes.

Patients and methods

Study design and patient selection

This prospective longitudinal study was performed at the retina unit of Ulucanlar Eye Training and Research Hospital from January 2015 to February 2016. The study protocol was approved by Ankara Numune Training and Research Hospital and the study was carried out in accordance with the Declaration of Helsinki. Written informed consent was obtained from each individual participant.

Twenty-four patients who underwent 27-G MIVS without any tamponade for the treatment of epiretinal membrane were enrolled. To be included in the study, each subject was required to meet all the following criteria: fundoscopic and optical coherence tomographic proven epiretinal membrane, the best corrected visual acuity (BCVA) was equal or less than 0.4 logMAR in the affected eye, no previous intervention for epiretinal membrane, and phakic crystalline lens status in both eyes. Moreover, the patients with any of the following conditions were excluded: ocular surface problems such as corneal scar, haze, and degeneration, glaucoma, uveitis, a history of ocular surgery or trauma, the patients who require tamponade usage at the end of the surgery, and those who were not sufficiently cooperative for Pentacam-HR examinations. The patients were excluded if they were pseudophakic in one or both eyes. Additionally, phakic patients with a cortical, anterior or posterior subcapsular, or advanced nuclear cataract were not included from the study since they may affect the reliability of lens densitometry measurements.

All patients underwent a comprehensive ophthalmic examination including BCVA testing using the Snellen chart, intraocular pressure (IOP) measurement with Goldman applanation tonometry, anterior segment examination with slit lamp biomicroscopy, dilated fundoscopy, optical coherence tomography, and Pentacam HR examination preoperatively. In order to calculate and compare visual acuity, Snellen acuity was converted to logMAR.

Lens densitometry measurements

Pentacam analysis to determine the lens densitometry was performed by the same experienced masked clinician using the same Pentacam HR-Scheimpflug imaging system and all measurements were taken under standard dim-light conditions. The automatic release mode was used to reduce operator dependent variables. In this mode, the instrument automatically determines when correct focus and alignment with the corneal apex are achieved and then performs a scan. In less than 2 s, the rotating camera captures up to 25 slit images of the anterior segment. Three measurements were performed per eye, and the one with the best alignment and fixation was selected for data analysis. Distorted images caused by high reflection that were not eligible for evaluation were not included in the analysis. The measurements were performed after an enough pupil dilatation. To induce pupil dilation, two drops of cyclopentolate hydrochloride 1% were administered 5 min apart and measurements were taken approximately 45 min after the last drop. Three-dimensional scan modes were used for the measurement of lens density.[18] The densitometry was analyzed using densitometry zones of the Pentacam device. As illustrated in Figure 1, the mean value was calculated in predefined 3D zones centred around the pupil centre (zone 1: 2.0 mm, zone 2: 4.0 mm, and zone 3: 6.0 mm).

These lens densitometry measurements were taken preoperatively and on the first week, first month, and third month postoperatively.

Surgical technique

In each case, the 27-g MIVS was performed under local anaesthesia by retrobulbar injection. All surgeries were performed using the Constellation Vitrectomy 27+ Total Plus Pak vitrectomy system (Alcon Laboratories, Fort Worth, Texas, USA) by the same surgeon (KS). Cannulas were inserted in the inferotemporal, superotemporal, and superonasal quadrants 3.0–4 mm posterior to the limbus. The conjunctiva and tenon

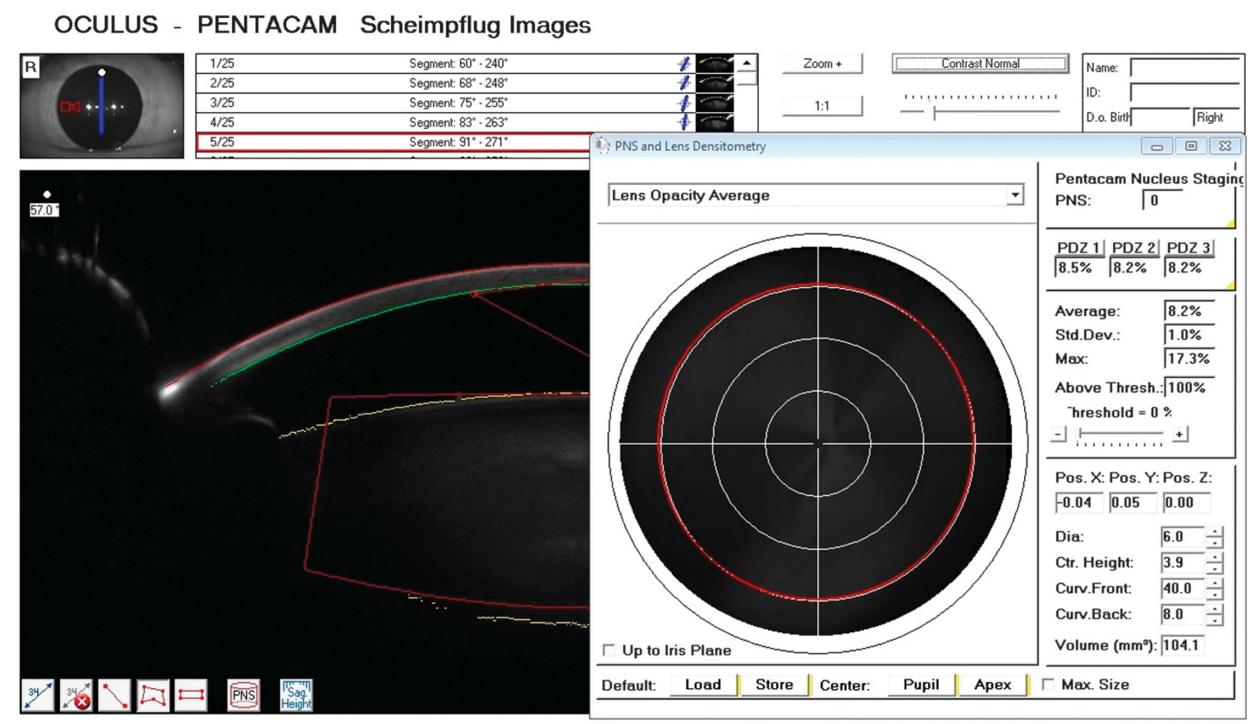

Figure 1 The lens densitometry analysis of Pentacam HR-Scheimpflug imaging is shown.

capsule were displaced over the sclera to avoid communication between conjunctival and scleral entry sites. Trocar cannulas were inserted tangentially at an angle of approximately 30°, parallel to the limbus. All eyes underwent core vitrectomy followed by removal of the posterior hyaloid membrane and vitreous traction. After vitrectomy, the surgeon used end-gripping microforceps to peel the epiretinal membrane from the macular surface within the vascular arcades. No intraocular tamponade including gas or silicon oil was used. At the end of the surgery, microcannulas were removed from the eye. The infusion line was clamped during removal of the microcannula and then unclamped after removal. The conjunctiva overlying the sclerotomy was slightly displaced to disrupt the alignment between both entry sites. Passage of the 27-G instruments through the microcannula was found to be uncomplicated and no sutures were needed to close the scleral or conjunctival openings. No intra-operative complications occurred in any eye.

Postoperative follow-up

All patients used postoperative topical antibiotic and steroid for two months with tapering dose. The BCVA, IOP measurement, slit lamp microscopy, and dilated fundus examinations were repeated on the first week, first month, and third month postoperatively. Patients with any sign of abnormal inflammation (overmuch anterior chamber and vitreous cells), iatrogenic lens or posterior capsule damage, an increase in IOP higher than 20 mm Hg were excluded from the study.

Statistical analysis

The study data were analysed using the Statistical Package for Social Sciences (SPSS) for Windows version 22.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were presented as mean ± standard deviation, frequency distribution, and percentages. Normal distribution of the variables was tested by visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk Test). For inter-group and intra-group comparisons, the paired samples t-tests were used for normally distributed variables and Wilcoxon signed rank tests were used for those that were not normally distributed. The statistical significance was set at $P<0.05$.

Results

This study included 24 patients who underwent 27-G MIVS without any tamponade and followed-up at least 3 months. Overall, 15 (62.5%) of the patients were female and 9 (37.5%) were male. The mean age of the patients was 64.55 ± 7.80 (range: 42–76) years. The mean operation time was 34.7 min (range 20–43 min).

The mean preoperative BCVA was 0.74 ± 0.27 (range: 1.3–0.4) logMAR. The mean overall BCVA was 0.38 ± 0.21

(range: 0.80–0.10) on the first week, 0.22 ± 0.18 (range: 0.70–0.00) on the first month, and 0.10 ± 0.11 (range: 0.40–0.00) on the third months postoperatively. There was a statistically significant improvement in the BCVA on the first week, first month, and third months compared to the preoperative BCVA ($P < 0.05$, for all).

As illustrated in Table 1, the first week postoperative lens densitometry values in the study eyes and healthy fellow eyes were similar to preoperative lens densitometry values in all lens zones ($P > 0.05$ for all). Table 2 demonstrates the lens densitometry values in the study and fellow eyes preoperatively and on the first month postoperatively. The mean lens densitometry values at Zone 1 and average lens densitometry values statistically significantly increased in the study eyes on the first month when compared with the preoperative values ($P = 0.011$, $P = 0.033$, respectively). Additionally, there were statistically significant differences regarding the mean lens densitometry values of Zone 1 and Zone 2, and also average lens densitometry values between the preoperative and third month postoperative values ($P = 0.003$, $P = 0.021$, $P = 0.009$, respectively) (Table 3). On the other hand, the densitometry values of fellow eyes were similar at preoperatively and all the postoperative follow-up periods ($P > 0.05$ for all).

Discussion

Despite the technical advances in retina and vitreous surgery, cataract remains as the most common postoperative complication and reduces visual acuity benefits of vitrectomy. Apparently, up to 80–90% of patients would require post-vitrectomy cataract surgery within 2 years after surgery.[8,19] This factor has led most of the previous vitrectomy reports for epiretinal membranes to potentially underestimate the benefits of vitreous surgery.

Regarding the rapid increase in lens density after PPV, there might be several possible mechanisms: intraoperative light toxicity,[6,20] intraoperative oxidation of lens proteins,[21] surgery-introduced changes of the lens' biochemical microenvironment, and postoperative factors (IOP, intraocular inflammation, and lens' biochemical microenvironment).[22,23] It was thought that crystalline lens exposure to ultraviolet light from the microscope during vitrectomy might produce nuclear sclerotic cataracts. Observation of cataract formation in mice exposed to ultraviolet light supports this hypothesis.[24] However, Taylor *et al*[25] reported that the ultraviolet radiation detected in human eyes exposed to high cumulative solar exposure, which exceeds that of the operating microscope did not cause increased nuclear sclerosis. If intraoperative light toxicity or oxidation of lens proteins is an important factor, longer operation time should lead to faster lens density progression and higher grade cataracts. However, Cheng *et al*[23] reported that although vitrectomy is a risk factor for nuclear sclerosis progression, the duration of vitrectomy does not increase the risk. In our study, cases with the same aetiology were selected, and operations were performed by the same surgeon to eliminate the differences that the surgical duration could create.

Table 1 Comparison of the preoperative and first week postoperative lens densitometry values in the study and fellow eyes

Parameter	*Study eyes*	*Fellow eyes*	P-*value*[a]
Mean densitometry at Zone 1			
Preoperative	9.27 ± 0.91	9.55 ± 1.14	0.135
Postoperative first week	9.31 ± 0.75	9.53 ± 1.31	0.213
P-value[a]	0.815	0.781	—
Mean densitometry at Zone 2			
Preoperative	8.92 ± 0.65	9.16 ± 1.11	0.303
Postoperative first week	8.96 ± 0.71	9.07 ± 1.23	0.347
P-value[a]	0.748	0.322	—
Mean densitometry at Zone 3			
Preoperative	8.96 ± 0.76	9.20 ± 1.03	0.211
Postoperative first week	8.78 ± 0.82	9.11 ± 1.45	0.130
P-value[a]	0.748	0.456	—
Mean average			
Preoperative	9.36 ± 1.55	9.51 ± 1.78	0.220
Postoperative first week	9.44 ± 1.78	9.68 ± 2.01	0.157
P-value[a]	0.889	0.711	—
Mean standard deviation			
Preoperative	2.11 ± 1.13	2.23 ± 1.27	0.839
Postoperative first week	2.55 ± 1.49	2.36 ± 1.45	0.606
P-value[a]	0.580	0.536	—
Mean maximum			
Preoperative	20.68 ± 17.33	22.57 ± 15.31	0.496
Postoperative first week	24.77 ± 15.41	26.36 ± 17.45	0.380
P-value[a]	0.288	0.501	—

Values were expressed as mean ± standard deviation. [a] Paired-samples *t*-test.

A study of 21 eyes using 'nonvitrectomizing' vitreous surgery for epiretinal membranes in patients older than age 50 years showed no increased nuclear sclerosis in surgical eyes compared with fellow eyes during a mean follow-up of 9.7 months.[26] A second study including longer follow-up of the 21 eyes in their prior study was reported no significant difference in nuclear sclerosis or myopic shift between the surgical and fellow eyes after a mean follow-up of 22 months by the same authors.[27] The two studies suggest that the increase in nuclear sclerosis after vitrectomy might be directly or indirectly related to the removal of vitreous gel.

The human crystalline lens exists in a relatively hypoxic state, a condition hypothesized to be important in preserving the clarity of lens.[28] The oxygen in the

Table 2 Comparison of the preoperative and first month postoperative lens densitometry values in the study and fellow eyes

Parameter	*Study eyes*	*Fellow eyes*	P-*value*[a]
Mean densitometry at Zone 1			
Preoperative	9.27 ± 0.91	9.55 ± 1.14	0.089
Postoperative first month	9.56 ± 0.98	9.66 ± 1.74	0.245
P-value[a]	**0.011**	0.591	—
Mean densitometry at Zone 2			
Preoperative	8.92 ± 0.65	9.16 ± 1.11	0.311
Postoperative first month	9.19 ± 0.77	9.11 ± 2.01	0.710
P-value[a]	0.073	0.407	—
Mean densitometry at Zone 3			
Preoperative	8.96 ± 0.76	9.20 ± 1.03	0.135
Postoperative first month	9.22 ± 1.02	9.07 ± 2.15	0.519
P-value[a]	0.087	0.201	—
Mean average			
Preoperative	9.36 ± 1.55	9.51 ± 1.78	0.203
Postoperative first month	9.60 ± 1.78	9.57 ± 2.33	0.617
P-value[a]	**0.033**	0.772	—
Mean standard deviation			
Preoperative	2.11 ± 1.13	2.23 ± 1.27	0.805
Postoperative first month	2.41 ± 1.60	2.41 ± 1.60	0.914
P-value[a]	0.387	0.227	—
Mean maximum			
Preoperative	20.68 ± 17.33	22.57 ± 15.31	0.406
Postoperative first month	26.14 ± 19.62	30.10 ± 20.45	0.201
P-value[a]	0.473	0.122	—

Values were expressed as mean ± standard deviation.
Bold values indicate $P<0.05$. [a] Paired-samples *t*-test.

Table 3 Comparison of the preoperative and third month postoperative lens densitometry values in the study and fellow eyes

Parameter	*Study eyes*	*Fellow eyes*	P-*value*[a]
Mean densitometry at Zone 1			
Preoperative	9.27 ± 0.91	9.55 ± 1.14	0.180
Postoperative third month	9.63 ± 0.86	9.65 ± 1.23	0.805
P-value[a]	**0.003**	0.602	—
Mean densitometry at Zone 2			
Preoperative	8.92 ± 0.65	9.16 ± 1.11	0.087
Postoperative third month	9.19 ± 1.11	9.17 ± 1.31	0.793
P-value[a]	**0.021**	0.822	—
Mean densitometry at Zone 3			
Preoperative	8.96 ± 0.76	9.20 ± 1.03	0.075
Postoperative third month	9.00 ± 1.23	9.11 ± 1.32	0.245
P-value[a]	0.118	0.433	—
Mean average			
Preoperative	9.36 ± 1.55	9.51 ± 1.78	0.083
Postoperative third month	9.67 ± 1.27	9.65 ± 2.17	0.605
P-value[a]	**0.009**	0.890	—
Mean standard deviation			
Preoperative	2.11 ± 1.13	2.23 ± 1.27	0.719
Postoperative third month	2.37 ± 1.25	2.29 ± 1.35	0.305
P-value[a]	0.451	0.536	—
Mean maximum			
Preoperative	20.68 ± 17.33	22.57 ± 15.31	0.471
Postoperative third month	28.48 ± 16.11	27.36 ± 18.45	0.767
P-value[a]	0.184	0.211	—

Values were expressed as mean ± standard deviation.
Bold values indicate $P<0.05$. [a] Paired-samples *t*-test.

avascular lens is provided by diffusion which means that the surrounding oxygen content is very important for the oxygen content within the lens and, consequently, for the formation of reactive oxygen species. In the absence of the vitreous gel since the vitreous is lacking as a diffusion barrier for the oxygen, molecular oxygen from the retinal vasculature reaches the lens, where it promotes oxidative damage of the lens nucleus, an increase in light scattering, and nuclear sclerotic cataract.[19] In support of this theory, Holekamp *et al*[29,30] also showed that postvitrectomy lens density was significantly lower in patients with ischemic diabetic retinopathy than with non-ischemic eyes, possibly associated with lower partial oxygen pressure in the vitreous cavity of ischemic eyes. In addition, when the vitreous is eliminated during vitrectomy, the level of ascorbate, which is a vitreous antioxidant that could neutralize the excess of oxygen in the vitreous cavity, decreases.[31]

Feng *et al*[10] found no significant difference in the rate of cataract extraction between 20-G and small G PPV. Almony *et al*[32] also reported that the disruption and removal of the vitreous gel itself, and not the gauge of vitrectomy, is associated with the significant progression of nuclear sclerotic cataract. Even so, only cases that underwent 27-G vitrectomy were included to present study to avoid differences that could be caused by gauge of vitrectomy.

Various lens opacity grading systems have been developed for grading cataracts. The Lens Opacity Classification System II (LOCS II) uses colour lens photograph standards that are compared with the patient lens that is graded on a scale from 0 to 4 by comparison with these standards.[33] The LOCS III, which is a more quantitative version of the LOCS II scale, uses slit-lamp photographs of the lens for each patient in the study with grading of nuclear colour and opalescence on a scale from 0.1 (clear) to 6.9 (very opaque) by masked graders rather than by the physician examiner.[34] Another different approach is to measure lens autofluorescence by fluorophotometry. Scheimpflug cataract imaging system, that is an objective cataract grading method using a modified slit beam, has been used to study the ocular lens for the past three decades.[35,36]

The changes in lens densities after vitrectomy were investigated with the above-mentioned techniques. Ogura and associates[21] evaluated autofluorescence in the lens at the centre along the ocular axis by fluorophotometry and found more autofluorescence in operated eyes than in fellow eyes 2 years after vitrectomy for idiopathic epimacular proliferation, which indicated an accumulation of fluorescent materials in the lens. Thompson *et al*[37] graded lenses by using the Chylack LOCS II lens grading scale of nuclear sclerosis and reported that the increase in nuclear sclerosis in the vitrectomized eye compared with the fellow eyes was about sixfold to sevenfold in all patient age ranges after vitrectomy. Melberg *et al*[38] reported that 79% of patients older than 50 years of age developed significant lens opacity in the surgical eye compared with the nonsurgical eye by using LOCS III. Ibán˜ez-Ruiz *et al*[39] found a significantly higher linear optical density obtained utilizing the Scheimpflug camera of the Oculus-Pentacam device in the 81 vitrectomized phakic eyes when compared to the non-vitrectomized eyes. Because the early stages of cataract are difficult to differentiate by using clinical classifications such as LOCS II, LOCS III, we used lens densitometry analysis of Pentacam HR-Scheimpflug imaging system, which is a quantitative and objective method providing precise and reproducible data related to lens clarity.[17]

To our knowledge, this is the first study to evaluate lens densitometry by densitometry analysis of Pentacam HR-Scheimpflug imaging system that enables an objective measurement method for progression of cataract after vitrectomy. The strengths of our study include the following: because of its prospective design, cases with similar surgical procedures and duration were included to the study. The surgeries were performed by the same surgeon and lens densitometry measurements were performed on the same postoperative days. And also the data collection was done with standardized imaging modality. The important limitations of this study are relatively small sample-size and short follow-up after vitrectomy.

This study suggests that 27-G MIVS vitrectomy might cause post-surgical lens density changes even in early postoperative months and vitreous may play an important role in protecting the transparency of the lens. Densitometry analysis of Pentacam HR-Scheimpflug imaging system is a quantitative and objective measurement method that can detect changes in the lens density that cannot be clinically determined and can help predict longitudinal cataract progression after vitrectomy.

Summary

What was known before

- Despite the technical advances in vitreoretinal surgery, cataract remains as the most common postoperative complication of vitrectomy.
- Scheimpflug imaging can provide quantitative, objective, and reproducible data related to lens densitometry to assess lens clarity.

What this study adds

- 27-G MIVS might cause post-surgical lens density changes even in early postoperative months.
- Pentacam HR-Scheimpflug imaging system can detect even clinically undetermined changes in lens density.

Conflict of interest

The authors declare no conflict of interest.

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