Association between morphological changes in filtering blebs and intraocular pressure increase after phacoemulsification

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BACKGROUND

Cataract formation is widely accepted as a complication of trabeculectomy. A greater risk of intraocular pressure (IOP) increase after cataract surgery has been shown in eyes with functioning filtering blebs, even with a corneal incision.

Previously, we demonstrated that cataract surgery after a successful trabeculectomy can negatively impact filtering bleb morphology using swept-source three-dimensional anterior segment optical coherence tomography (3D AS-OCT), which may lead to increased IOP[1]. 3D AS-OCT revealed a significant decrease in maximum bleb height, maximum bleb wall thickness, and the ratio of the hypo-reflective space of the bleb wall following phacoemulsification[1].

It is important to investigate how to prevent an IOP increase after cataract surgery in eyes with functioning filtering blebs.

PURPOSE

To identify factors that are associated with an IOP increase after cataract surgery in eyes with functioning filtering blebs.

MATERIALS AND METHODS

Study design: a retrospective cohort study

Study subjects:

Thirty-three phakic eyes of 32 patients with functioning filtering blebs after primary trabeculectomy that had undergone phacoemulsification (phaco) were included in this study.

Definition of "functioning filtering bleb": an IOP ≤15 mm Hg and a > 20% reduction in IOP without glaucoma medication or additional glaucoma surgery after trabeculectomy.

Exclusion criteria:

a. eyes that were followed up for less than 6 months after phaco
b. eyes with neovascular glaucoma or primary angle-closure glaucoma
c. eyes that had undergone any previous ocular surgery except trabectome surgery
d. eyes for which the region of interest for 3D AS-OCT measurements was not available due to a tight eyelid and/or a narrow lid fissure

Methods

1. The subjects were classified into **an IOP-increase group** and **an IOP-stable group**, according to whether or not they had an IOP increase of ≥ 2 mm Hg at 6 months after phaco. Pre-phaco IOP, time interval between trabeculectomy and phaco, and changes in 3D AS-OCT parameters, including maximum bleb height, maximum bleb wall thickness, and the ratio of the hypo-reflective space of the bleb wall, were compared between the two groups.
2. The subjects were also divided into **a low-IOP group (< 10 mm Hg)** and **a high-IOP group (≥ 10 mm Hg)**, based on the pre-phaco IOP. They were evaluated for changes in IOP and 3D AS-OCT parameters between before phaco and at 6 months after phaco.

Outcome measures

1) IOP
2) Glaucoma medication
3) 3D AS-OCT parameters

Analysis of cross-sectional characteristics of filtering blebs

Eyes were examined using swept-source 3D AS-OCT (SS-1000 CASIA and/or CASIA2, Tomey Corporation, Nagoya, Japan) and were evaluated with the CASIA Bleb Assessment Software 4.0L program (Tomey Corporation).

3D AS-OCT parameters

① Maximum bleb height (Fig.1)
② Maximum bleb wall thickness (Fig. 1)
③ Ratio of hypo-reflective space of the bleb wall (Fig. 2)

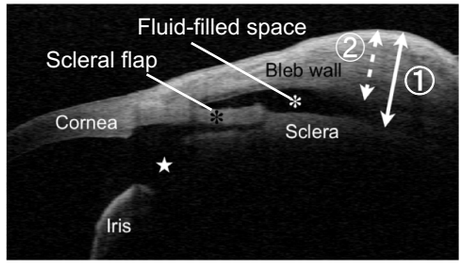

FIGURE 1. Maximum bleb height and maximum bleb wall thickness. The entire bleb was analysed.

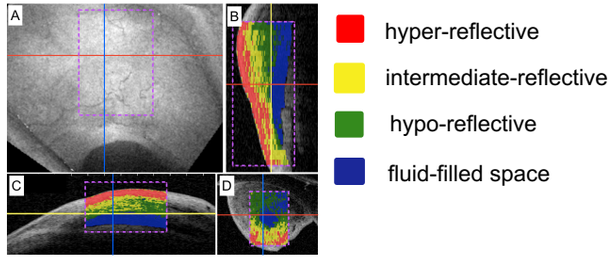

FIGURE 2. Ratio of hypo-reflective space of the bleb wall. Hypo-reflective space volume / total bleb wall volume in the region of interest: a 5×7×3-mm cuboid (purple dotted line).

RESULTS

TABLE 1. Background characteristics (IOP increase group vs IOP stable group)

	Group classification		
	IOP increase	IOP stable	P value
Patients (n)	18	14	
Eyes (n)	19	14	
Mean age (years) Mean ± SD	67.2 ± 8.6	67.3 ± 13.0	0.975[a]
Sex (M/F)	9/10	5/9	0.723[b]
Operated eye (R/L)	11/8	9/5	1[b]
Type of glaucoma (POAG/EXG/NTG/SG/CM)	11/3/2/3/0	9/0/2/2/1	0.542[b]
Time interval from Trab to Phaco (days) Mean ± SD	470.3 ± 135.2	440.7 ± 109.7	0.706[a]
Mean IOP before Phaco (mm Hg) Mean ± SD	8.4 ± 3.2	8.8 ± 2.2	0.627[a]
Mean IOP at 6 months after Phaco (mm Hg) Mean ± SD	11.9 ± 3.8	8.3 ± 2.4	0.004[a]
Maximum bleb height (mm)	1.57 ± 0.41	1.38 ± 0.31	0.529[a]
Maximum bleb wall thickness (mm)	0.97 ± 0.23	1.05 ± 0.29	0.760[a]
Ratio of hypo-reflective space of the bleb wall	0.339 ± 0.118	0.322 ± 0.101	0.418[a]

[a] Mann-Whitney U test; [b] Fisher's Exact Probability test; EXG = exfoliation glaucoma; NTG = normal tension glaucoma; SG = secondary glaucoma; CM = combined mechanism; Trab = trabeculectomy; Phaco = phacoemulsification; IOP = intraocular pressure; SD = standard deviation

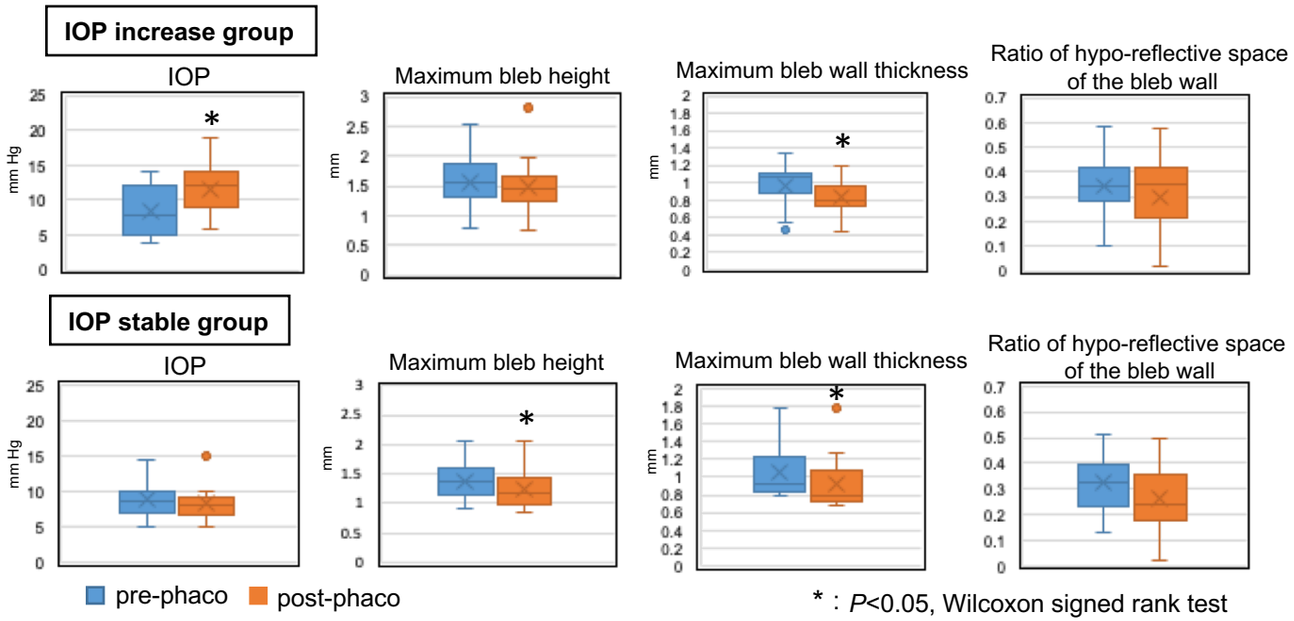

FIGURE 3. Comparison between IOP increase group and IOP stable group.

TABLE 2. Background characteristics (High IOP group vs Low IOP group)

	Group classification		
	High IOP	Low IOP	P value
Patients (n)	11	21	
Eyes (n)	11	22	
Mean age (years) Mean ± SD	68.3 ± 10.9	66.7 ± 10.6	0.694[a]
Sex (M/F)	7/4	7/15	0.136[b]
Operated eye (R/L)	10/1	10/12	0.022[b]
Type of glaucoma (POAG/EXG/NTG/SG/CM)	5/2/2/2/0	15/1/2/3/1	0.546[b]
Time interval from Trab to Phaco (days) Mean ± SD	495.6 ± 157.6	438.7 ± 102.5	0.295[a]
Mean IOP before Phaco (mm Hg) Mean ± SD	11.7 ± 1.6	7.0 ± 1.8	<0.001[a]
Mean IOP at 6 months after Phaco (mm Hg) Mean ± SD	12.5 ± 3.1	9.0 ± 3.5	0.007[a]
Maximum bleb height (mm)	1.42 ± 0.36	1.52 ± 0.39	0.439[a]
Maximum bleb wall thickness (mm)	0.98 ± 0.23	1.02 ± 0.28	0.690[a]
Ratio of hypo-reflective space of the bleb wall	0.302 ± 0.117	0.347 ± 0.106	0.286[a]

[a] Mann-Whitney U test; [b] Fisher's Exact Probability test; EXG = exfoliation glaucoma; NTG = normal tension glaucoma; SG = secondary glaucoma; CM = combined mechanism; Trab = trabeculectomy; Phaco = phacoemulsification; IOP = intraocular pressure; SD = standard deviation

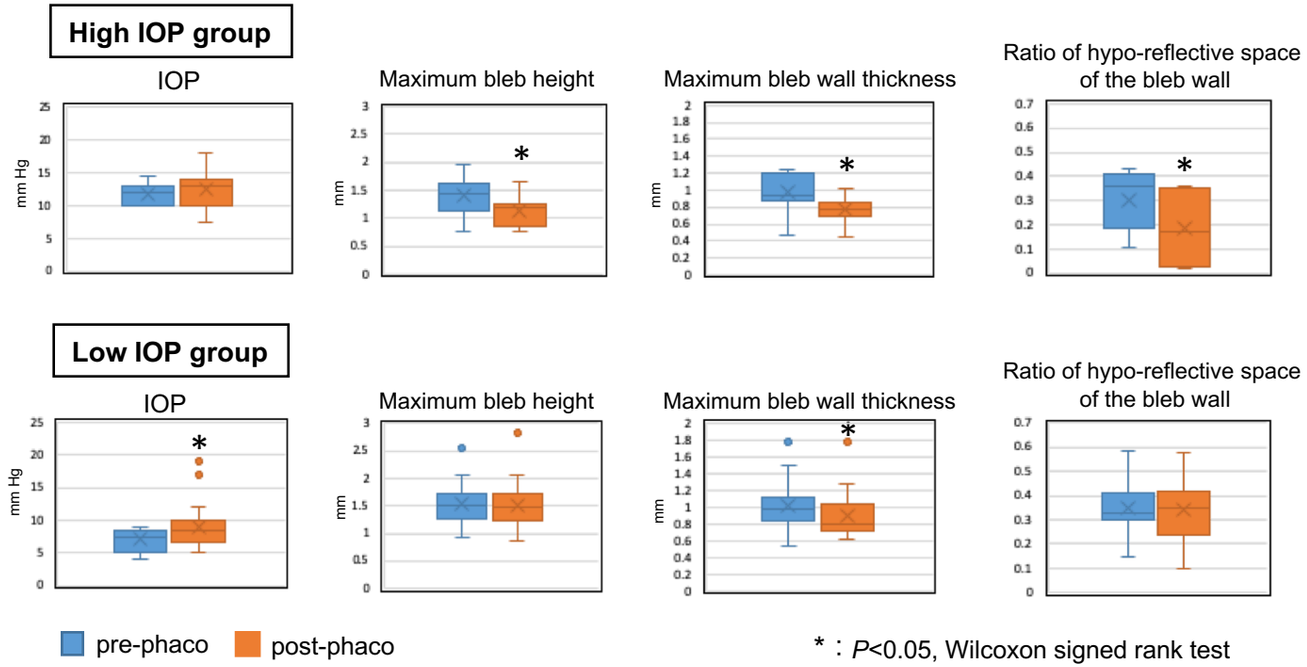

FIGURE 4. Comparison between high IOP group and low IOP group.

KEY FINDINGS

・In the comparison between the IOP-increase and IOP-stable groups, there were no significant differences in the pre-phaco IOP, the time interval between trabeculectomy and phaco, or the 3D AS-OCT parameter changes, including maximum bleb height, maximum bleb wall thickness, and the ratio of the hypo-reflective space of the bleb wall (Table 1).

・When it comes to the pre-phaco IOP, the eyes in the low-IOP group showed a significant IOP increase along with a significant decrease in maximum bleb wall thickness at 6 months after phaco (Fig. 4). The eyes in the high-IOP group showed substantial decreases in all the 3D AS-OCT parameters without a significant increase in IOP at 6 months after phaco, although there were 3 eyes that resumed glaucoma eye drops after phaco (Fig. 4).

DISCUSSION

Previous studies have shown that the time interval between trabeculectomy and phaco, the IOP values before phaco, and morphological changes in filtering blebs following phaco have influence on increased IOP after phaco[1,2]. In this study, although we did not find any significant differences in these factors between the IOP-increase and IOP-stable groups, we demonstrated the discrepancy between the IOP increase and morphological changes in filtering blebs after phaco by analysing the eyes based on the pre-phaco IOP.

The mechanism of aqueous humour drainage from the filtering bleb has not been fully understood. However, transconjunctival, lymphatic, and venous drainage routes have been postulated, and postoperative IOP as well as the morphology of the filtering bleb are most likely to be determined by the predominance and combination of these drainage routes[3].

The presence of conjunctival lymphatic drainage is considered to be a key determinant of drainage longevity[3]. Hence, well-functioning filtering blebs with an IOP < 10 mm Hg are likely to have effective lymphatic drainage. Lymphatic capillaries are more vulnerable to stress due to a single layer of overlapping and interdigitated endothelial cells, when compared with blood vessels[3]. Therefore, lymphatic capillaries could possibly be damaged at the time of phaco, presumably because of the high volume of fluid and viscoelastic materials entering into the filtering bleb, which may lead to increased IOP following phaco with a small change in the morphology of filtering blebs. In contrast, since filtering blebs in the high IOP group had little avascularity in their bleb walls with an IOP ≥ 10 mm Hg, they are likely to be venous-drainage dominated, and the postoperative inflammatory reaction in the conjunctiva may cause the morphological changes in filtering blebs.

CONCLUSION

Morphological changes in filtering blebs may not be a major factor for an IOP rise after cataract surgery, especially in eyes with well-functioning filtering blebs.

REFERENCES

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2) Dada T, et al.. Cataract surgery in eyes with previous glaucoma surgery: pearls and pitfalls. *J Curr Glaucoma Pract* 2013;7:99–105.
3) Yu Dao-Yi, et al. The critical role of the conjunctiva in glaucoma filtration surgery. *Prog Retin Eye Res* 2009;28:303-328.