· Brief Report ·

Imaging and refractive characteristics of different types of late postoperative capsular block syndrome

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Abstract
● **AIM:** To propose a novel classification system for late postoperative capsular block syndrome (CBS) based on the turbidity of intracapsular fluid, and to investigate the imaging and refractive changes before and after Nd:YAG laser posterior capsulotomy for each subtype.
● **METHODS:** A retrospective analysis was performed on 5 eyes from 5 patients with late postoperative CBS. Patients were categorized into turbid (3 eyes) or clear (2 eyes) types based on the turbidity of intracapsular fluid. Uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), refractive status, slit-lamp images, Pentacam Scheimpflug data, and ultrasound biomicroscopy (UBM) images were evaluated before and 1mo after successful Nd:YAG laser posterior capsulotomy.
● **RESULTS:** Nd:YAG laser posterior capsulotomy significantly improved UCVA and BCVA in all 5 late CBS eyes. Pentacam imaging: turbid intracapsular fluid showed hyperreflection between posterior capsule and intraocular lens (IOL); clear fluid showed hyporeflection. UBM: posterior capsule was clear in turbid type but poorly defined in clear type. Capsulotomy increased aqueous depth only in clear type. Refractive changes: turbid fluid induced myopic shift. Clear type myopic shift was due to anterior IOL displacement and clear fluid-induced concave lens effect.
● **CONCLUSION:** Nd:YAG laser posterior capsulotomy is effective for late CBS. Turbid and clear late CBS types differ in imaging (Pentacam/UBM) and refractive mechanisms, supporting the proposed classification's clinical value.
● **KEYWORDS:** late postoperative capsular block syndrome; Nd:YAG posterior capsulotomy; Pentacam imaging; ultrasound biomicroscopy; refractive status
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INTRODUCTION
Capsular block syndrome (CBS) is a rare complication of continuous curvilinear capsulorhexis (CCC) in cataract surgery[1]. Late postoperative CBS is much less frequent, and occurs several months to years after cataract surgery[2]. Usually, late CBS is defined as an accumulation of turbid (milky-white) liquefied substance between the intraocular lens (IOL) and posterior capsule, but we also observed clear fluid in certain patients. The aim of present study was to propose a new classification for late postoperative CBS according to intracapsular fluid states and evaluate the Pentacam Scheimpflug and ultrasound biomicroscopy (UBM) imaging, as well as refractive characteristics before and after neodymium:yttrium-aluminum-garnet (Nd:YAG) laser posterior capsulotomy.

PARTICIPANTS AND METHODS
Ethical Approval The study was approved by the Medical Ethics Board of the Second Affiliated Hospital of Xi'an Jiaotong University (2025ES004).

Cases of late postoperative CBS in patients treated from June 2017 to June 2022 were retrospectively reviewed. Late postoperative CBS was diagnosed by slit lamp examination as the presence of capsular bag distension and accumulation

Table 1 Basic information of patients

Case	Sex	Age	Eye	Time	DM	AL	IOL power	IOL type	Size of CCC	Fluid type
1	Male	58y	Left	7y	No	24.1 mm	19.5 D	Acrysof SA60AT	4.7 mm	Turbid
2	Female	65y	Right	6y	Yes	21.4 mm	26 D	Hoya PY60R	4.5 mm	Turbid
3	Female	70y	Right	4y	Yes	23.4 mm	19 D	Hoya PY60R	4.4 mm	Turbid
4	Male	72y	Left	1.5y	No	27.2 mm	8.5 D	Rayner 620H	4.5 mm	Clear
5	Female	62y	Right	1y	No	26.1 mm	13.5 D	Rayner 920H	4.2 mm	Clear

DM: Diabetes mellitus; AL: Axial length; CCC: Continuous curvilinear capsulorhexis; IOL: Intraocular lens.

Table 2 Parameters of the patients before and after Nd:YAG posterior capsulotomy

Case	UCVA (logMAR)		BCVA (logMAR)		Refraction		SEQ change (D)	IOP (mm Hg)		AQD (mm)		
	Pre	Post	Pre	Post	Pre	Post		Pre	Post	Pre	Post	Change
1	0.82	0.1	0.52	0	-1.50DS/-1.00DC×90	-0.25DS/-1.00DC×90	1.25	15.3	16.2	3.98	4.07	0.09
2	1	0.22	0.4	0.1	-2.00DS	-0.50DS	1.50	16.2	15.6	3.54	3.53	-0.01
3	0.92	0.1	0.7	0	-1.00DS/-0.50DC×80	-0.50DC×80	1.00	14.5	13.5	3.88	4.02	0.14
4	0.7	0.1	0.22	0.05	-1.00DS/-0.50DC×100	-0.50DC×90	1.00	15.6	16.5	3.42	4.27	0.85
5	0.3	0.1	0.05	0	-1.50DS	-0.75DS	0.75	17.2	16.3	3.33	4.23	0.90

Nd:YAG: Neodymium:yttrium-aluminum-garnet; UCVA: Uncorrected visual acuity; BCVA: Best corrected visual acuity; DS: Diopter sphere; DC: Diopter cylinder; IOP: Intraocular pressure; SEQ: Spherical equivalent; Pre: Pre-laser capsulotomy; Post: Post-laser capsulotomy; AQD: Aqueous depth.

of turbid or clear liquefied substance more than 6mo after uneventful phacoemulsification with CCC and IOL implantation. Five eyes of 5 patients with late CBS were included. Three eyes were turbid fluid, and other two eyes were clear fluid.

Nd:YAG laser (Visulas Yag III, Carl Zeiss Meditec, Germany) posterior capsulotomy was performed by the same clinical expert (Wang JM), to form an opening about 4 mm in diameter with the cross-pattern method. Pulses of 1.8 to 2.0 mJ were applied, and the total energy used was about 40-80 mJ. Uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), refractive status (manifest refraction was performed by a single experienced optometrist), intraocular pressure (IOP; CT-80, Topcon Corporation, Japan), fundus examination, anterior segment photography (camera system, SLM-7E, KANGHUA, China), Pentacam Scheimpflug imaging (Pentacam 70700, OCULUS Optikgerate GmbH, Germany), and UBM (Suoer, SW-3200L, China) were performed before and 1mo after capsulotomy. All patients got IOP measurement 1h after capsulotomy and were prescribed 1% prednisolone acetate drops 3 times a day and 0.5% timolol 2 times a day for 1wk. The fifth patient also underwent itrace aberration instrument (Tracey Technologies Company, USA) examination to evaluate visual quality before and after laser treatment.

The aqueous depth (AQD) was obtained using UBM from 5 to 10 consecutive anterior chamber images. AQD was measured as the distance from the endothelium of the cornea to the IOL anterior surface at the corneal center. The measurement was repeated on separate days by the same experienced technician.

RESULTS

Characteristics of 5 eyes of 5 patients who had late CBS were reviewed in Table 1. In turbid group, all of 3 cases implanted with hydrophobic acrylic IOL. The axial length (AL) data came from IOL Master 500 measurement before phacoemulsification.

The important ocular parameters of the patients before and after capsulotomy was summarized in Table 2. All the patients complained of blurry or hazy vision before laser treatment. After capsulotomy, the UCVA and BCVA improved in all the patients. The post-laser logMAR BCVA improved. All patients with turbid type were myopic before capsulotomy, the post-laser spherical equivalent (SEQ) was reduced. In turbid type, the AQD of 2 patients increased slightly after capsulotomy, other patients were stable. In clear type, the AQD of 2 patients increased obviously after capsulotomy, which were more remarkable than the turbid type.

Slit lamp examination showed all the patients with turbid type had a moderate backward extension of the posterior capsule and the presence of turbid liquefied substance (milky-white) between the IOL and the posterior capsule, and also had dense fibrosis ring of the capsulorhexis opening accompanied by residual white cortex fragments (Figure 1A1). Two of 3 patients are associated with posterior capsular opacification. In clear type, an exceedingly posterior extension of the posterior capsule and transparent fluid between the IOL and the posterior capsule were observed (Figure 1A2), also proliferating fibrocytes in sub-anterior capsular (not dense fibrosis ring) were visible (Figure 2), but there were no residual

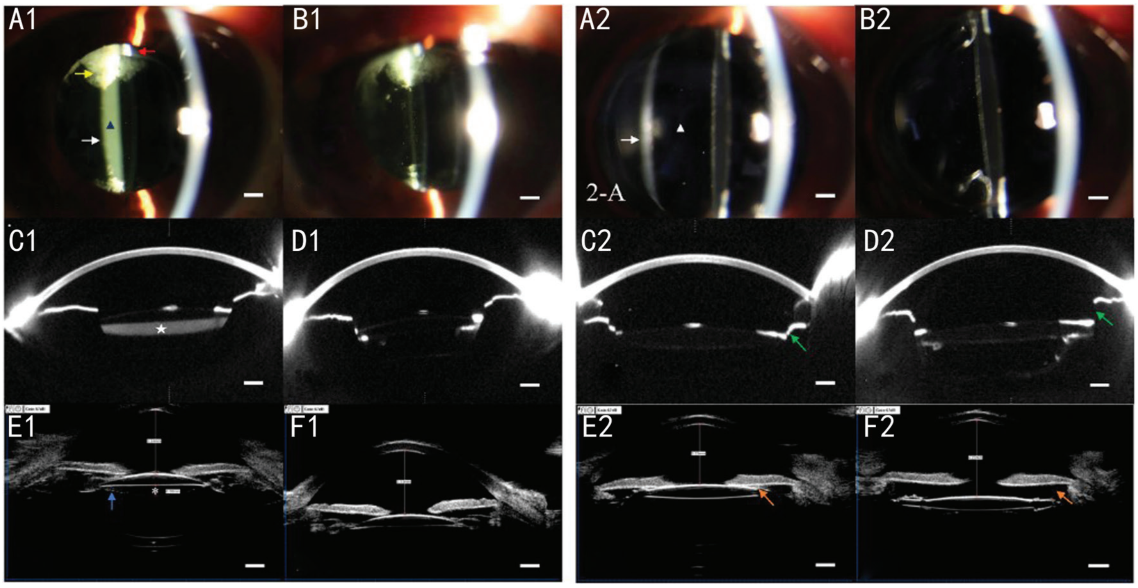

Figure 1 Slit lamp, Pentacam Scheimpflug, and UBM images of turbid and clear type of late CBS before and after laser posterior capsulotomy A1–F1: Turbid type of late CBS; A2–F2: Clear type of late CBS. A1, B1: Slit lamp photograph showing the presence of a turbid liquefied substance (black triangle) between the IOL and the posterior capsule (white arrow), dense fibrosis ring of the capsulorhexis opening (red arrow), residual white cortex fragments (yellow arrow), the turbidity disappeared after capsulotomy; C1, D1: Pentacam Scheimpflug showing the turbid fluid was a hyperreflection space behind IOL (white pentagram) and disappeared after capsulotomy; E1: UBM showing the turbid fluid was hyporeflection (white star) and the posterior capsule was displayed clearly (blue arrow); F1: AQD was 3.54 mm pre-laser and 3.53 mm post-laser. A2, B2: Slit lamp photograph showing clear fluid (white triangle) between the IOL and the extremely backward-extending posterior capsule (white arrow); The clear fluid disappeared, and the backward-extending posterior capsule returned to its normal position after capsulotomy; C2, D2: Pentacam Scheimpflug image showing the clear fluid was hyporeflection, posterior capsule was not shown. The IOL and the iris were contact (green arrow). The contact between the IOL and the iris was reversed after capsulotomy (green arrow). E2: UBM showing the clear fluid was hyporeflection but the posterior capsule wasn't shown. AQD was 3.33 mm pre-laser. The iris was contact to IOL (organge arrow). F2: AQD was 4.23 mm, the contact between IOL and iris was reversed (organge arrow) after capsulotomy. Scale bar: 1 mm. UBM: Ultrasound biomicroscopy; CBS: Capsular block syndrome; IOL: Intraocular lens; AQD: Aqueous depth.

cortex fragments. No Inflammatory anterior chamber cellular reaction was observed in all the cases. After capsulotomy, the turbid and clear fluid flowed into the vitreous cavity, and the backward-extending posterior capsule returned to its normal position (Figure 1B1, 1B2).

The Pentacam Scheimpflug imaging showed different reflection space in each type (Figure 1C1, 1C2). But the imaging failed to capture the displacement of the posterior capsule behind the IOL, neither turbid nor clear type. The hyperreflection in turbid type disappeared after laser treatment (Figure 1D1). The gap between the anterior surface of IOL and the iris was increased after laser in clear type (Figure 1C2, 1D2).

For UBM image, the posterior capsule was displayed clearly in turbid (Figure 1E1), invisible in clear type. UBM image was also used to measure the AQD. After capsulotomy, AQD didn't have obvious changes in turbid type (Figure 1E1, 1F1), whereas it was significantly increase in clear type (Figure 1E2, 1F2), also the contact between the IOL and the iris was reversed after capsulotomy (Figure 1E2, 1F2).

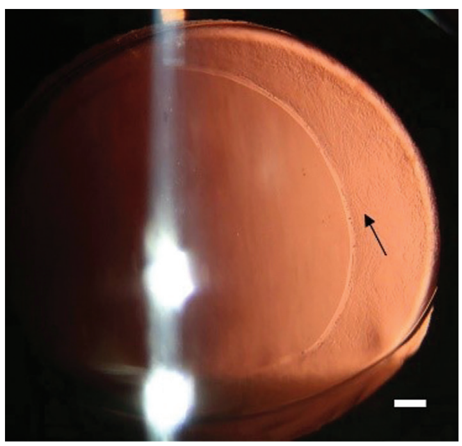

Figure 2 Sub-anterior capsular proliferating fibrocytes (black arrow) in clear type late capsular block syndrome Scale bar: 1 mm.

For patient No.5, the logMAR BCVA was 0.05, but she complained of intense hazy visual interference before laser treatment. The itrace aberration instrument was used to evaluate visual function. The modulation transfer function (MTF) curves from internal and total eye increased 1wk after capsulotomy (Figure 3).

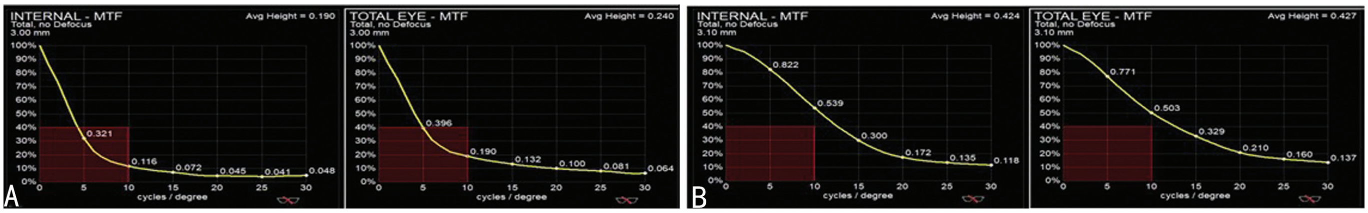

Figure 3 The itrace aberration instrument examination for No.5 patient with clear type late capsular block syndrome A: Pre-laser, the average height of internal-MTF was 0.190, the average height of total eye-MTF was 0.240; B: Post-laser, the average height of internal-MTF increased to 0.424, and the average height of total eye-MTF increased to 0.427. MTF: Modulation transfer function.

DISCUSSION

The fluid between the posterior capsule and IOL was invariably described as turbid[3-10]. There are few cases of clear fluid accumulation between the IOL and posterior capsule[11-14]. Except for Vlasenko *et al*[14], most of the authors didn't explicitly define them as late CBS, because of the clear fluid. Aboshiha *et al*[11] even attributes it to early CBS.

The patients observed in this study were late CBS in terms of onset time after phacoemulsification (1-7y). The composition of clear fluid was different from that of early CBS induced by residual ophthalmic viscosurgical devices, according to CBS classification method proposed by Miyake *et al*[1], they should be classified into late CBS with clear fluid[13]. Hereafter, we proposed stratified them into turbid and clear types according to intracapsular fluid states.

The reflection condition may be related to intracapsular fluid. There is no consensus as to the contents of the intracapsular fluid[15-16]. Usually, the imaging of the turbid fluid was a hyporeflective space on UBM, while was hyperreflective on anterior segment optical coherence tomography and Pentacam Scheimpflug imaging[3-4,6,8,10,17-18]. We got similar imaging in turbid type. But Al-Mulla and Al-Rushoud[19] reported that aspiration of the turbid fluid in one case of late postoperative CBS identified Propionibacterium acnes, which showed hyper-reflection in UBM image. Based on these results, the hyper-reflection on UBM may be an indicator of the presence of infection.

The content and volume of the turbidity lead to different converging and scattering effects on light, and different degrees of myopia and astigmatism in each patient. In our study, the refraction states in turbid type were all myopia, and the degree of myopia decreased after laser capsulotomy, which is consistent with other literatures[10,20]. We speculated that the change of SEQ was mainly due to IOL position and the effect of turbid fluid. There was no significant change in AQD, which means no significant change in IOL position. The refractive power caused by turbid fluid in this study should be a convex lens, leading to myopia, which is the main factor of SEQ change in this type. Lin *et al*[21] also observed the changes of diopter, and they thought that turbid CBS after routine phacoemulsification had caused the original refraction to shift toward myopia and had a slight hyperopic shift after YAG. One patient in Sandhaus *et al*[5] also showed hyperopic shift. We cannot draw a conclusion of hyperopic shift after YAG at current stage, but there may be a tendency for this change.

YAG laser posterior capsulotomy is the priority selection for treating late CBS, with a high success rate[5-6,8,18]. But the risk of increased IOP and recurrent CBS can't be avoided[22]. In rare cases where the turbidity was intense, and the laser aiming beam could not be focused on the posterior capsule, surgical aspiration of turbid fluid in the capsular bag was suggested[3,17]. In this study, visual acuity was significantly improved in turbid type after capsulotomy. But when the turbid fluid positive for propionibacterium acnes[23-24], capsulotomy may lead to the spread of infection, the surgical approach should be considered.

Here we observed two eyes with clear fluid late CBS, the UBM imaging was consistent with those reported by Vélez *et al*[13]. After capsulotomy, AQD was significantly increased, and the gap between the iris and IOL was significantly enlarged, which means the IOL was significantly backward displaced. One millimeter in anterior IOL displacement correlates to 2.00 D of induced myopia for a corneal surface[25], that means, for eyes from patients 4 and 5, the posterior movement of the IOL after laser should correlate with a predicted hyperopic shift about 1.70 D and 1.80 D, and an actual hyperopic shift (SEQ change), 1.00 D and 0.75 D. Therefore, we speculate that the clear fluid produced a concave lens effect and caused hyperopia, which is completely different from turbid fluid. Although there was no dense fibrosis ring of the capsulorhexis opening, sub-anterior capsular proliferating fibrocytes were also observed in clear fluid group. Therefore, we believe that the mechanism of clear fluid formation is also residual lens epithelial cells metaplastic change and fibrosis, resulting in changes of osmotic pressure in the bag, with a backward expansion of the posterior capsular, which is similar to the mechanism of turbid type. BCVA impairment may not be significant in clear fluid, as shown in patient 5, but visual quality had been significantly affected. After laser treatment, MTF value and vision quality were significantly improved, BCVA was increased, and the blurry vision of patient disappeared. This suggests that even clear fluid late CBS with good BCVA still needs laser therapy to improve visual quality.

We found that clear and turbid fluid in late CBS distinguished not only in the character of liquefied substance but also Scheimpflug and UBM images, especially the changes in AQD before and after capsulotomy. Then we calculated that the refractive effects caused by clear and turbid fluid were also different, which may be related to the different scattering effects caused by the composition.

In addition, an interesting finding was that the two patients with clear fluid, both with high myopia, were implanted with Rayner hydrophilic IOLs. Whether high myopia, type and design of IOLs are the risk factors for developing clear type still needs further study.

For the limitation of this study, the sample size was too small to draw any conclusion. Also, we didn't get fluid for component analysis. Whether diabetes mellitus is a risk factor for turbid type late CBS also needs further observation with a larger sample.

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