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Eye injuries caused by high intensity macro and micro focused ultrasound treatment: a case report

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Abstract

Background High Intensity Macro and Micro Focused Ultrasound (HIFU) is a safe and effective method for the treatment of skin laxity. However, the application of high-intensity focused ultrasound energy on eyelids has been associated with potential ocular complications including traumatic cataract, iridocyclitis, and conjunctival hemorrhage, among others.

Case presentation A 40-year-old female developed blurred vision in her left eye after receiving HIFU treatment on binocular eyelids, and her left far vision was 20/66. The examination revealed left eye iris depigmentation and conjunctival hemorrhage. Both eyes exhibited multiple white streaking or tadpole-shaped opacities in the lenses.

Conclusion Excessive ultrasonic energy generated by HIFU can cause protein denaturation, leading to conditions such as traumatic cataract, visual impairment, injuries to the iris and conjunctiva when applied to the eyes. We recommend that individuals undergoing cosmetic treatment in the periorbital region should be highly aware of the possible ocular side effects.

Keywords HIFU, Traumatic cataract, Case report

Background

High Intensity Macro- and Micro- Focused Ultrasound (HIFU) as a non-invasive treatment demonstrates anti-aging, skin firming, lifting, and rejuvenating effects [1–3]. This technology delivers focus high-energy ultrasound energy of 65–75℃ on tiny points at different levels of the skin and induces a thermal effect. These focused points are called thermal coagulation points (TCPs). That is to say, high-energy focused ultrasound makes the focused dots produce high temperature, reaching the temperature of collagen coagulation and denaturation, and through the denaturation and contraction of collagen and the induction of wound repair reaction, it can achieve the tension and pulling effect of deep dermis and fascia [2, 4, 5]. A female patient in our report had blurred vision, ocular redness and other symptoms after HIFU treatment.

Case presentation

One case of eye injury caused by HIFU treatment, a high intensity bundled ultrasound skin surgery instrument (SHURINK-A 50/60Hz (A35100.02(3)), Classys Inc., Korea), was reported and followed up for one year.

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A 40-year-old female presented to our hospital with acute onset of left eye blurred vision persisting for half a day. Her history revealed that the day before, she underwent HIFU treatment at a beauty salon. The treatment involved ultrasound energy at a level of 0.9 J/cm2 targeting the eyes and focal tissue layers to a depth of 2.0 mm. Additionally, the ultrasonic device emitted focused ultrasonic energy in double lines, with eight laser emission holes (Fig. 1-E). Each line measured 20 mm in length, with a spacing of 1.5 mm between each thermal coagulation point (TCP), and a spacing of 3 mm between each row of lines. Immediately following the procedure, the patient experienced mild pain and blurred vision in the left eye, accompanied by redness and discomfort. She has a history of bilateral Femtosecond-assisted laser in situ keratomileusis (FS-LASIK) refractive surgery one year ago, 20/20 unaided vision in both eyes after surgery with no other ocular history or family history.

After thorough examination, the patient exhibited a visual acuity of 20/20 in the right eye and 20/66 in the left eye (Table 1). The intraocular pressure of both eyes was within the normal range. Positive ocular signs: Anterior chamber flare (+) of the right eye and two parallel rows of multiple strips about 0.5–2 mm long were seen inside the lens (Fig. 1-C). Localized bleeding in the conjunctiva of the upper eyelid of the left eye (Fig. 2-C), mixed conjunctival hyperemia (+), and infratemporal conjunctival hemorrhage (Fig. 2-B), a large number of pigmented Keratic Precipitates (KPs) were seen below the corneal endothelial surface. There was a substantial presence of floating cells and pigmented particles within the anterior chamber, as evidenced by a positive Tyndall effect (++) (Fig. 2-D). Relative Afferent Pupillary Defect (RAPD) (+). Focal and map-like iris pigment detachment were observed in the left eye at approximately 8–9 and 4 o'clock positions and scattered dotted damage can be seen in the peripheral iris (Fig. 2-E). The capsular contraction (Fig. 2-A), vacuolar changes and pigment deposition were seen on the surface of the lens of the left eye, and the upper and lower rows of 0.5–3 mm long tadpole like opacity were seen inside, and the posterior capsule was opaque (Fig. 1-D). Based on the patient's medical history and signs, diagnosed as traumatic cataract in both eyes and iridocyclitis in the left eye. Since the lens opacity morphology was consistent with the ultrasonic probe energy focus (Fig. 1-E), it was speculated that the cataract in this patient was caused by HIFU.

After three days of treatment with topical anti-inflammatory three times a day each (Prednisolone acetate Ophthalmic Suspension 1% (Allergan), Levofloxacin Eye Drops 0.5% (Santen) and Pranoprofen Eye Drops (Senju), the patient's visual acuity in the left eye improved to 20/28.5 (Table 1). Conjunctival hyperemia and bleeding improved significantly. The subcorneal KP and anterior chamber reactions were resolved. The lens tadpole-like opacity and anterior capsular contraction did not change from before. The reason for the improvement of the patient's vision after treatment was the improvement of iridocyclitis, the subsidence of anterior chamber flash, and the restoration of ciliary muscle modulation.

After six months of follow-up, the patient continued to experience blurred vision in the left eye, with the visual acuity of 20/28.5 (Table 1). Physical examination revealed that the lens opacity of the right eye was similar to before, the anterior capsular contraction of the left eye was better than before, and the lens opacity spreaded to the periphery (Fig. 1-F, G,H).

After one year, the patient reported no changes in the right eye, while the left eye continued to experience blurred vision. Visual acuity of the left eye was 20/25 (Table 1). The lens opacity in the right eye remained unchanged, while the left eye exhibits anterior capsular opacity accompanied by a decrease in lens transparency. When comparing the changes in Tracey refraction and Dysfunctional Lens Index (DLI) values over 3 follow-up visits using Optimize iTrace (Tracy Technologies Inc., USA), we observed persistent changes in Tracey refraction values. The increase in DLI value in the right eye indicates that the opacity has shifted off the optical axis, and restoration of ciliary regulation function may improve visual quality. Conversely, the decrease in DLI value in the left eye suggests worsening lens opacity, impaired function, and reduced visual quality (Fig. 3), likely due to progressive deterioration of lens opacity.

The patient's left eye visual acuity decreased and the absolute value of Mean Deviation (MD) increased, while the Pattern Standard Deviation (PSD) value remained basically unchanged. This indicates a general visual field defect in the patient, which may be attributed to lens opacity. There was no significant change in the field of vision of the right eye (Fig. 4).

Discussion and conclusion

HIFU delivers high energy focused ultrasound energy to the targeted skin tissue layer, inducing a thermal coagulation effect and promoting collagen regeneration and growth of elastic fibers, achieve the purpose of facial skin tightening and body contour plasticity, its safety and effectiveness have also been confirmed [2]. Previous reports have mentioned minor complications associated with HIFU, such as corneal stromal, anterior uveitis, blurred vision and iris pigment detachment [1, 2, 6–8]. In additon, there have been reports of such severe traumatic cataracts leading to lens related surgery [9–11].

Since the shape of the secondary cataract lens opacity of HIFU is consistent with the focus of the ultrasonic probe energy, it is the underlying cause of traumatic cataract. Previous studies have found that localized ultrasonic

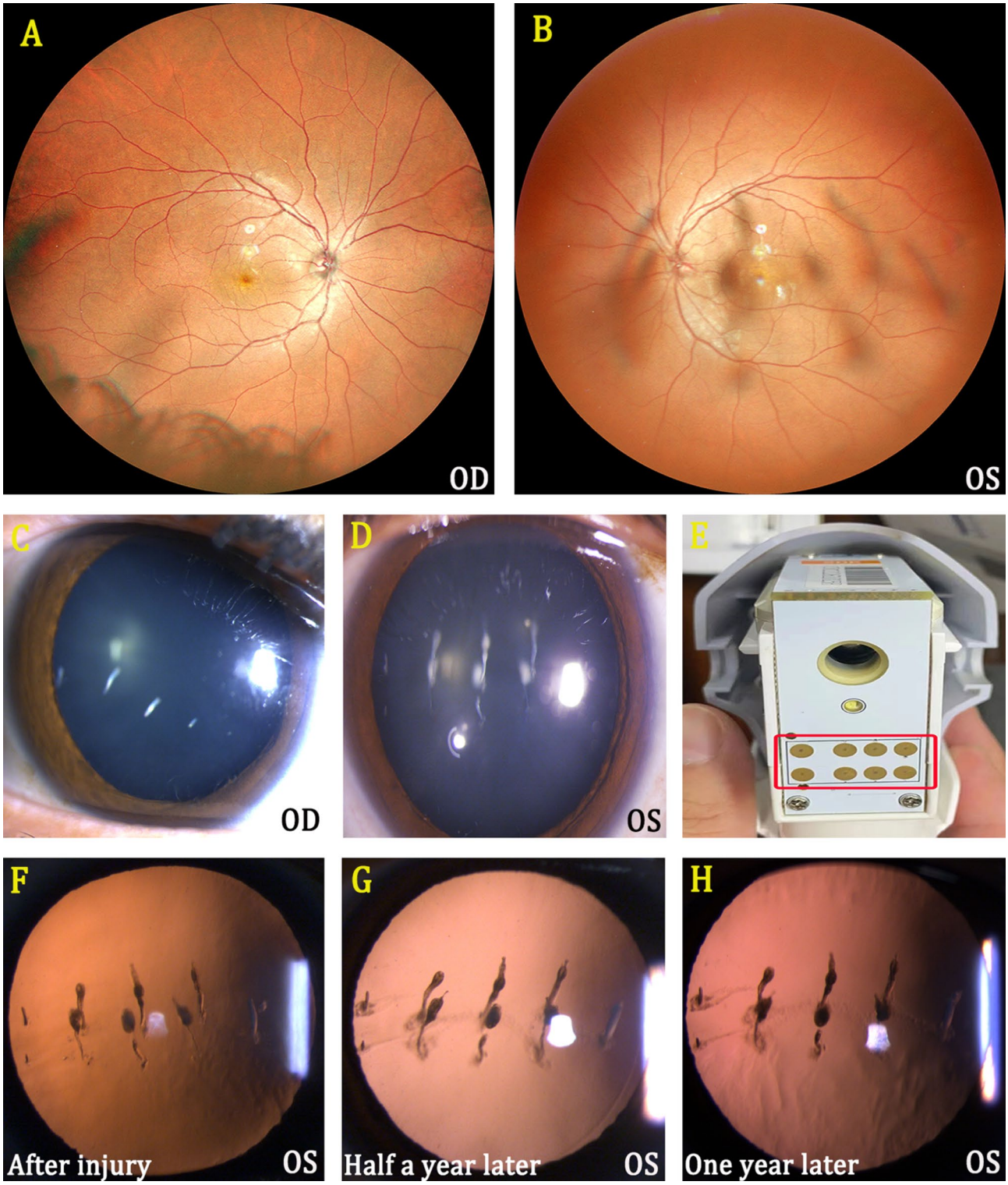

Fig. 1 Lens opacification induced by HIFU. (**A**,**B**) Bilateral fundus photography. (**C**,**D**) Bilateral lens opacity (**E**) Ultrasound probe. Red box: ultrasonic energy excitation point. (**F**, **G**,**H**)Lens opacity diffusion

Table 1 Visual acuity, best corrected visual acuity and ocular symptoms change over time

FOLLOW UP	OD			OS		
	VA	BCVA	Ocular symptoms	VA	BCVA	Ocular symptoms
Before injury	20/16	20/13 with refraction of -0.25 DS/-0.25 DC×105°		20/20	20/16 with refraction of +0.25 DS/-0.50 DC×105°	
After injury	20/20	20/20 with refraction of 0.00 DS/-0.25 DC×105°	Anterior chamber flare (+); lens opacity	20/66	20/40 with refraction of +0.50 DS/-1.0 DC×106°	Conjunctival hemorrhage; iris pigment detachment; KP(+);Tyn(++);RAPD(++);lens opacity; capsule contraction
Three days after the injury	20/20	20/20 with refraction of 0.00 DS/-0.50 DC×100°	Lens opacity	20/28.5	20/22 with refraction of +0.50 DS/-0.50 DC×125°	Lens opacity; capsule contraction
Half a year after the injury	20/16	20/16 with refraction of +0.50 DS/-0.25 DC×105°	Lens opacity	20/28.5	20/20 with refraction of +1.75 DS/-0.75 DC×175°	Lens opacity spread
One year after the injury	20/20	20/16 with refraction of -0.25 DS/0.00 DC×0°	Lens opacity	20/25	20/22 with refraction of +0.75 DS/-1.0 DC×155°	Lens opacity spread

VA: Visual acuity **BCVA**: Best corrected visual acuity **KP**: Keratic Precipitate **Tyn**: Tyndall effect **RAPD**: Relative Afferent Pupillary Defect

energy can denature the protein inside the lens, resulting in lens opacity [12–14]. Ultrasound has thermogenic effect [13]. Microscopically, these TCPs appear as discrete tadpole-shaped thermal damage zones (TIZ) with a volume of approximately 1 mm3, from the anterior capsule continuous to cortex. This morphological change, including size, shape, and position to infer TCP volumes and uniformity, is similar to the transparent tissue-mimicking material when treated with HIFU [5]. It resembles the cloudiness of the tadpole head due to the thermal effect of ultrasonic energy to denature the lens protein. Its outer round vacuole and cortical vacuole-like consideration may be that the lens pump-leakage balance is destroyed due to mechanical and thermal damage, water and sodium retention, epithelial cell swelling and vacuole-like changes, and over time, the vacuole absorption capsule shrinks and spreads slowly, the anterior capsule and epithelial cells are destroyed and crystal protein denatures, so that the structure and spatial conformation change, water-soluble protein decreases, and the insoluble protein rises leads to a decrease in crystal transparency. As a result, the degree of traumatic cataracts will increase continually, resulting in unforeseen severe visual impairment. In this case, thermal injury resulting in a change in the depth of ultrasound action due to the use of the wrong ultrasound transducer or excessive ultrasound energy or poor patient coordination was considered [15].

HIFU has been approved to treat the periocular area, but it crucial to note that improper usage can lead to severe eye conditions, including traumatic cataract, iridocyclitis and conjunctival hemorrhage. This should be emphasized and strictly condemned that clinics with poor training and knowledge treat the eyelid. Therefore, we suggest that better visualization system and more strict operator training are needed. During the operation, the ultrasonic probe should be avoided from being placed on the eyebrow arch and eyelid to prevent eye injury. Meanwhile, we advocate use of eye shields of some kind for periocular HIFU or advocate avoidance of periocular HIFU all together.

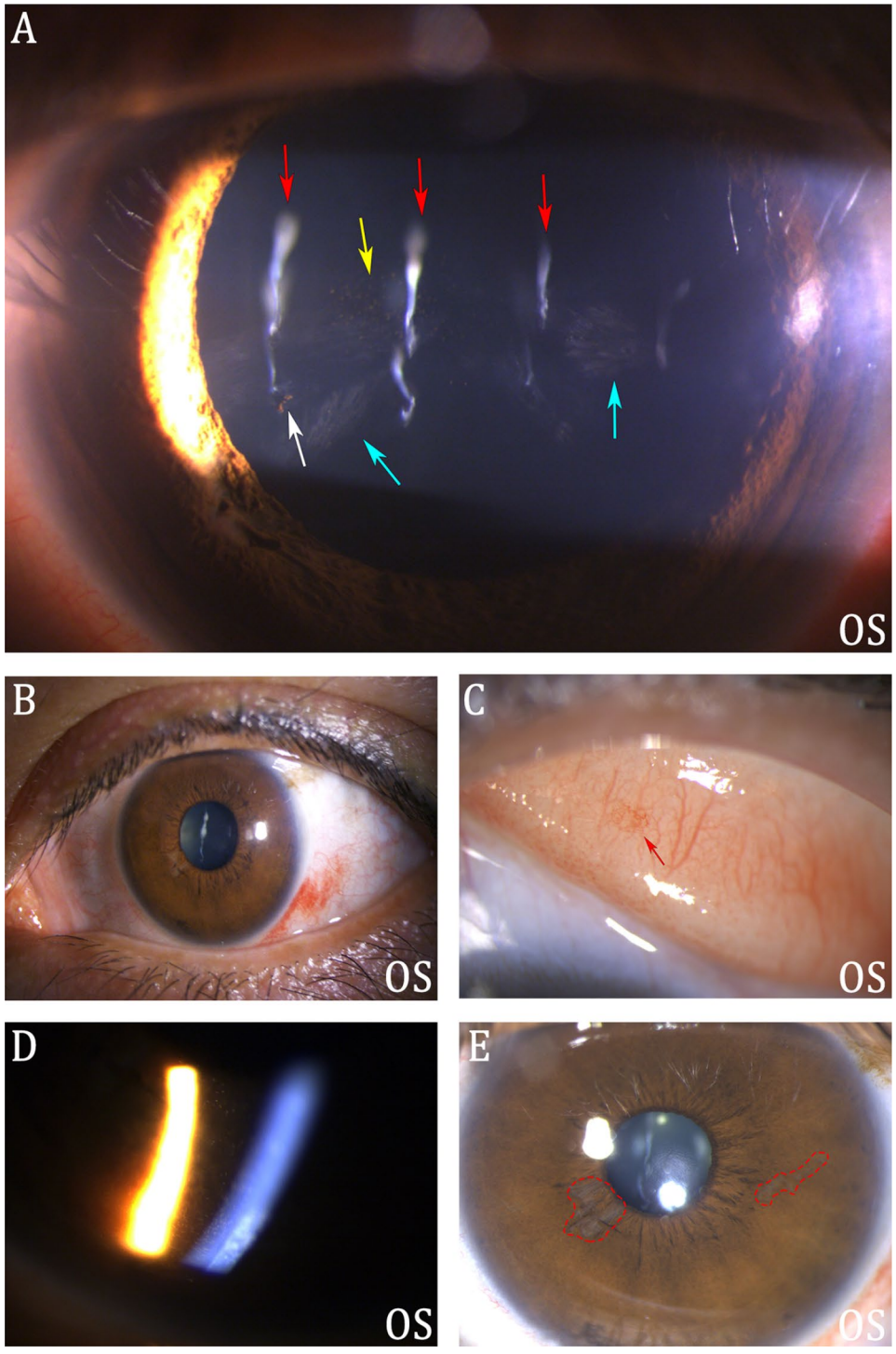

Fig. 2 Eye injury caused by HIFU. (**A**) White arrow: iris pigment attached to the anterior capsule of the crystal; red arrow: lens opacity; blue arrow: capsule contraction; yellow arrow: anterior chamber cells and pigmented granules. (**B**, **C**) Conjunctival hemorrhage. Red arrow: bleed-point. (**D**) Anterior chamber plankton cells and pigmented granules. (**E**) Iris pigment detachment. Red circle: damaged iris

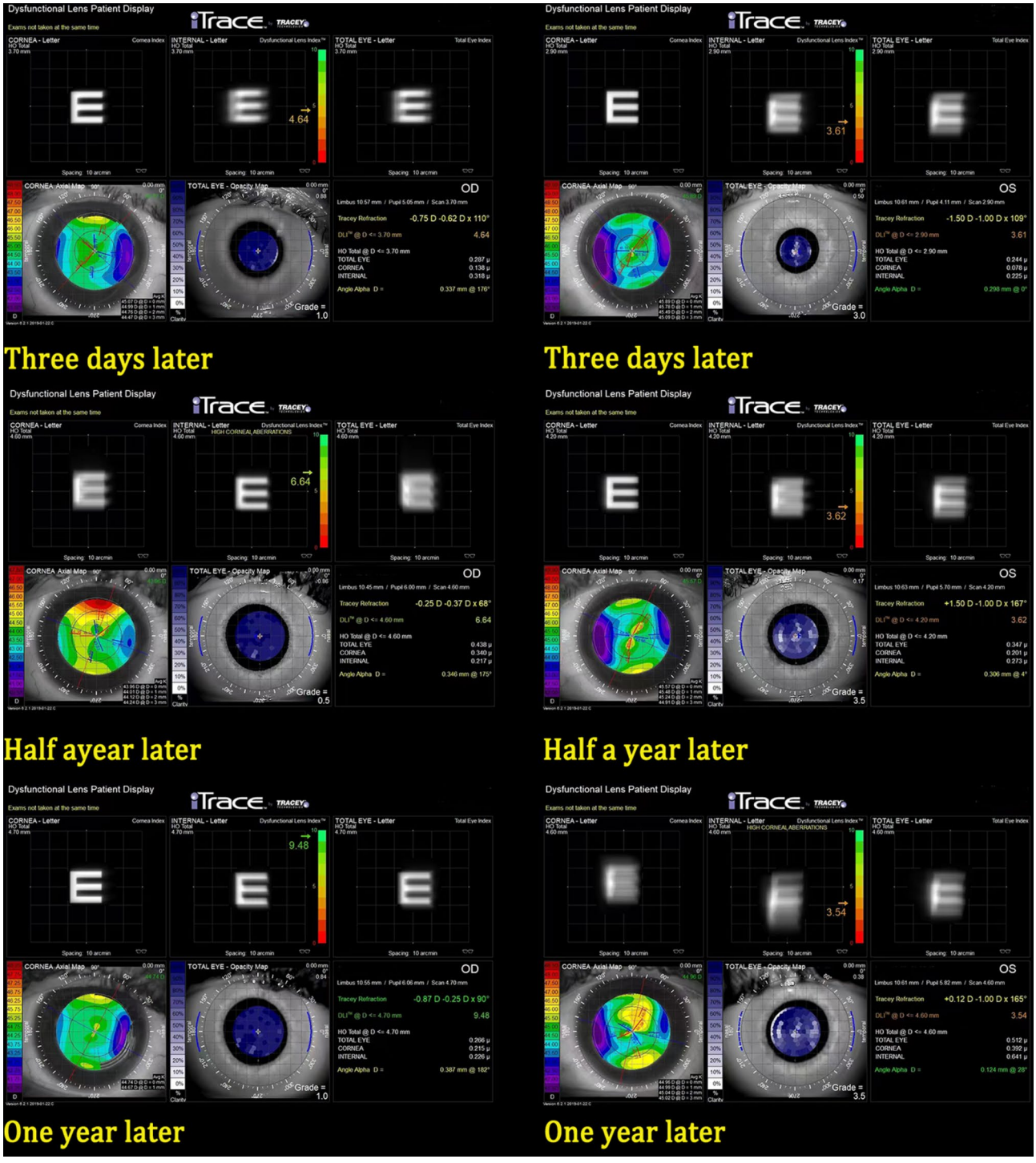

Fig. 3 Tracey Refraction and Dysfunctional Lens Index (DLI) values changing over time. DLI in the right eye gradually increases and decreases in the left eye

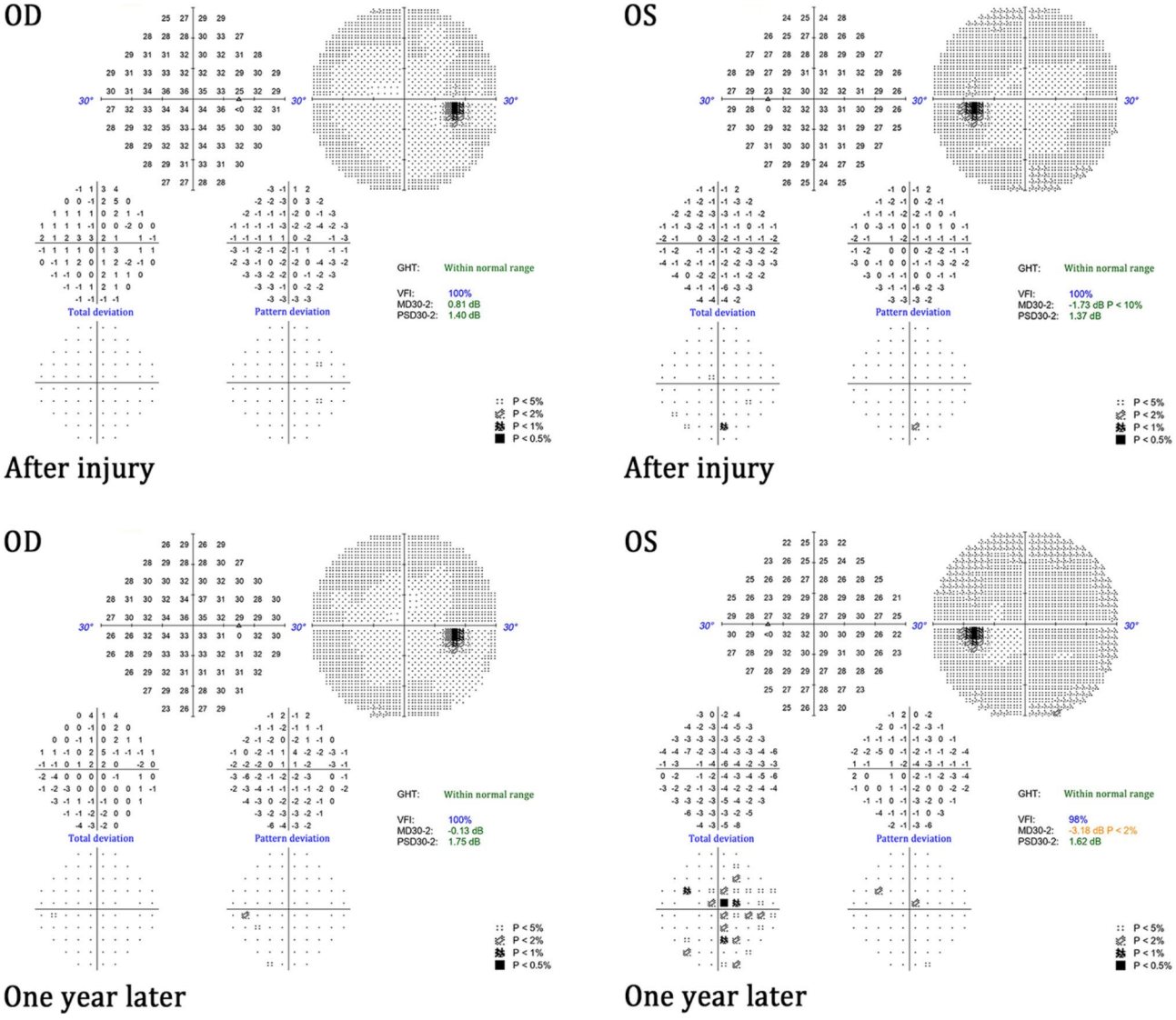

Fig. 4 Decreased visual acuity in the left eye indicates the diffusion of lens opacity

Abbreviations

HIFU	High intensity macro and micro focused ultrasound
KP	Keratic precipitate
RAPD	Relative afferent pupillary defect
DLI	Dysfunctional lend index
MD	Mean deviation
PSD	Pattern standard deviation
VA	Visual acuity
BCVA	Best corrected visual acuity

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Author contributions
GBX and YJL participated in the design of the study. LH and JLY performed the data analysis. LH, JLY, and CJ drafted the manuscript. All authors interpreted the data. NL, YXL, NZ, and CJ revised the manuscript and contributed to intellectual content. All authors read and approved the final manuscript.

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Data availability
Data is available upon request made to the corresponding author.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written informed consent was obtained from patient for publication of this case report and accompanying images.

Competing interests
The authors declare no competing interests.

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