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A case of Nd:YAG laser-induced traumatic macular hole with good visual prognosis after vitrectomy with inverted internal limiting membrane technique

Satoshi Kuwayama [a], Aki Kato [a,*], Soichiro Kuwayama [a], Syunsuke Fujii [a], Kazuhiko Sugitani [a], Atsushi Osada [b], Yuichiro Ogura [a], Tsutomu Yasukawa [a]

[a] Department of Ophthalmology and Visual Science, Nagoya City University Graduate School of Medical Sciences, Nagoya, Aichi, Japan
[b] Osada Eye Clinic, Kobe, Hyogo, Japan

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ABSTRACT

Purpose: To report an accidental case of traumatic macular hole caused by Nd:YAG laser in a dermatology clinic.
Observations: A 24-year-old woman sustained a laser injury to her right eye while practicing a dermatologic treatment using a Nd:YAG laser without wearing protective goggles. She noticed sudden-onset and progressing visual loss in her right eye and consulted an ophthalmologist 2 days after injury. The best-corrected visual acuity (BCVA) of her right eye decreased to 20/133. Fundus examination showed white parafoveal flecks with a central retinal hemorrhage and underlying serous retinal detachment. The retinal sensitivity in this lesion deteriorated. Two weeks later, a full-thickness macular hole (FTMH) developed in the affected eye. She was referred to Nagoya City University Hospital where the laser damage described was observed. The BCVA was 20/67. She underwent pars plana vitrectomy performed using the inverted internal limiting membrane (ILM) flap technique and gas tamponade. One week postoperatively, the FTMH closed, the BCVA in her right eye improved to 20/50, and the retinal sensitivity in the macular area mostly improved. The BCVA gradually improved and reached 20/25 9 months after the injury.
Conclusions and importance: Protective goggles must be worn when using an Nd:YAG laser in the laboratory or clinical setting. In the unfortunate event of a FTMH, early vitrectomy with an inverted ILM flap technique can be helpful to achieve a good visual prognosis.

1. Introduction

Although the hazards of lasers are well known, laser injuries still occur. In Ophthalmology, an Nd:YAG laser device is commonly used to treat ocular diseases such as after cataract, open-angle glaucoma, and acute angle-closure glaucoma. Nd:YAG laser capsulotomy performed to treat after cataract is a well-established technique that is relatively non-invasive and by itself does not cause retinal damage. However, if the retina is irradiated accidently with high pulse energy by Nd:YAG laser, retinal damage, such as a macular hole, potentially can result in irreversible visual disruption.[1]

An Nd:YAG laser device, especially a Q-switched Nd:YAG laser device, is also commonly used in dermatology to remove blemishes, freckles, bruises, moles, and tattoos. The Q-switched Nd:YAG laser is particularly harmful because it emits short pulses of high energy in durations of a few to tens of nanoseconds and can irradiate the retina invisibly.[1]

While most accidents related to Nd:YAG laser occur in the laboratory, commercially available medical devices also cause retinal injuries, most of which occur when the clinician is not wearing protective eye wear.[2]

We report a case of a traumatic macular hole in a medical staff who was applying dermatologic Nd-YAG laser without wearing protective goggles and was underwent vitrectomy with an inverted internal limiting membrane (ILM) flap technique leading to a relatively good visual outcome.

* Corresponding author. Department of Ophthalmology and Visual Science, Nagoya City University Graduate School of Medical Sciences, 1 Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya, Aichi, 467-8601, Japan.
E-mail address: akikato@med.nagoya-cu.ac.jp (A. Kato).

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2. Case report

A 24-year-old female nurse accidently injured her right eye when exposed to an Nd:YAG laser. She was applying Q-switched 1,064-nm Nd:YAG laser onto clear plastic film to practice a procedure in a cosmetic surgery. She was not wearing protective goggles during the training and noticed a sudden visual disturbance in her right eye, which was followed without a medical examination. However, because the vision in the right eye did not improve during the following 2 days, she visited an eye clinic.

Her best-corrected VA (BCVA) was 20/133 in the right eye and 20/13 in the left eye. In the right eye, while slit-lamp examination showed no marked changes in the anterior segment, fundus examination showed three whitened spots with a central retinal hemorrhage in the parafoveal area and adjacent white-to-grayish spots (Fig. 1A). Optical coherence tomography (OCT) showed destruction of the retinal layer structure with hyperreflectivity, obscuration of the ellipsoid zone, and a serous retinal detachment (SRD) at the fovea (Fig. 1B). Humphrey field analyzer (HFA) perimetry showed decreased retinal sensitivity in the injured area (Fig. 1C). The left eye was normal. She was diagnosed as having damage to her right eye caused by the Nd:YAG laser reflecting off a plastic film and hitting the retina. Nevertheless, since macular hole formation was not observed, she was followed without intervention. Two weeks later, a full-thickness macular hole (FTMH) was diagnosed in the right eye (Fig. 2A and B) she was referred to Nagoya City University Hospital for surgery.

The BCVA in her right eye was 20/100. While the retinal whitening and retinal hemorrhage were reduced, a FTMH was observed (Fig. 3A and B). Fundus autofluorescence imaging showed hyperfluorescence consistent with the FTMH and low fluorescence consistent with damage to the retinal pigment epithelium (RPE) (Fig. 3C). Early-stage fluorescein angiography (FA) and indocyanine green angiography (ICGA) showed hyperfluorescence consistent with the FTMH (Fig. 3D and E); no fluorescein leakage was seen in late-phase FA and ICGA (Fig. 3F and G). Hypofluorescence on ICGA corresponded to hypo-autofluorescence associated with damage of the RPE.

Four weeks after the initial injury, the patient underwent pars plana vitrectomy using a 25-gauge trocar system. Briefly, a core vitrectomy was performed after intentional induction of a posterior vitreous detachment by assisted visualization with triamcinolone acetonide crystals. The ILM was visualized with indocyanine green dye, peeled, flipped, and placed over the macular hole (inverted ILM flap technique). Fluid-air exchange was followed by sulfur hexafluoride gas injection and postoperative prone posturing. Ten days postoperatively, closure of the macular hole was confirmed (Fig. 4A), the SRD and retinal edema were negligible (Fig. 4B), and the BCVA in the right eye improved to 20/50, while destruction of the retinal structure and obscuration of the outer retinal layers remained (Fig. 4B and C). Eight weeks postoperatively, the macular hole remained closed and the injured region became slightly grayish, suggesting local damage of the RPE (Fig. 5A). The external limiting membrane and the ellipsoid zone in the macula showed a tendency to recover (Fig. 5B). Although the retinal sensitivity in the injured area was mostly improved, a less sensitive region partially remained (Fig. 5C). The BCVA of the right eye gradually improved and reached 20/25 9 months postoperatively.

3. Discussion

Since the first report of accidental laser injury to the macula by Rathkey[3] in 1965, laser injuries continue to occur in clinical, industrial, military, and recreational settings and most accidents happen when individuals are not wearing protective goggles. In the current case, the

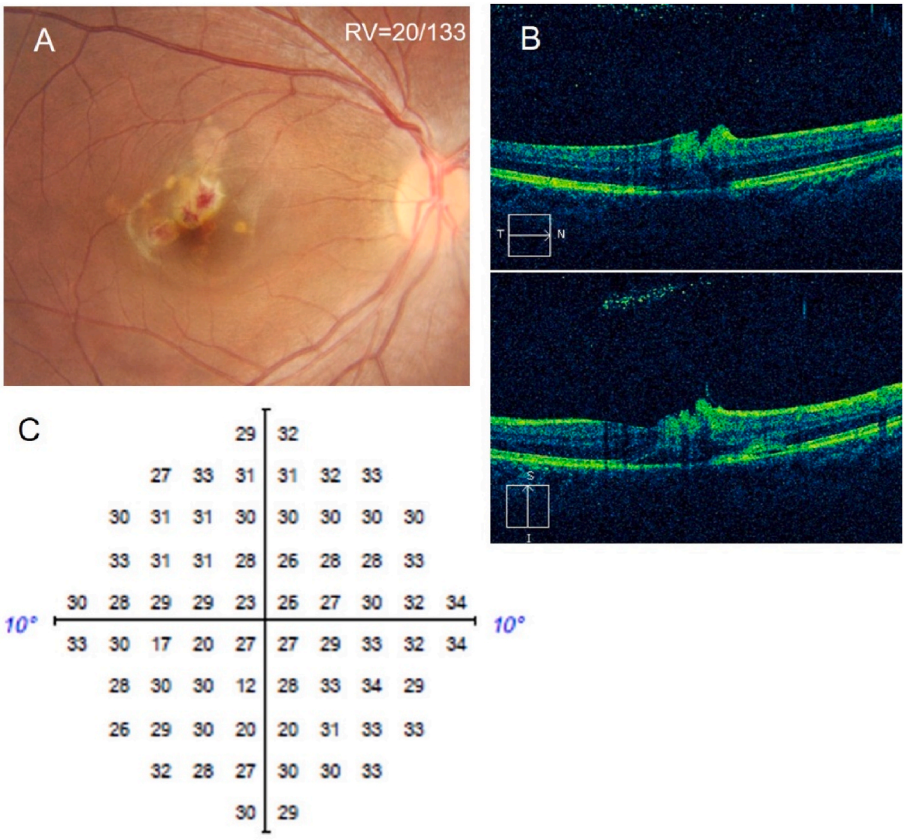

Fig. 1. (A) At the first ophthalmologic visit, a fundus image of the right eye shows whitened flecks with a central retinal hemorrhage and adjacent white-to-grayish spots. (B) Optical coherence tomography images show destruction of the retinal layer structure, obscuration of the ellipsoid zone, and a serous retinal detachment in the fovea. (C) Humphrey field analyzer perimetry (10-2) shows decreased retinal sensitivity consistent with the injured area.

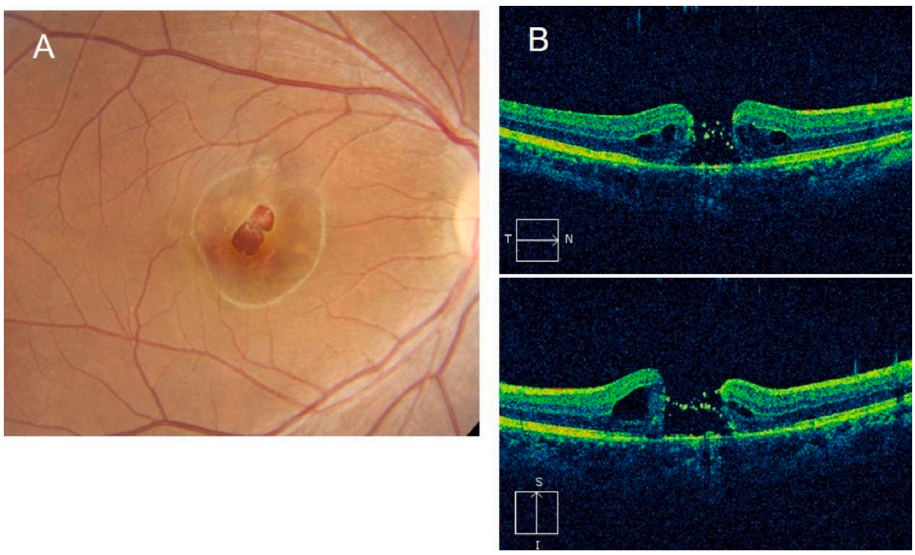

Fig. 2. (A) Two weeks after the injury, a fundus image of the right eye shows an irregular macular hole. (B) Optical coherence tomography images of the right eye show a full-thickness macular hole with intraretinal cystic changes.

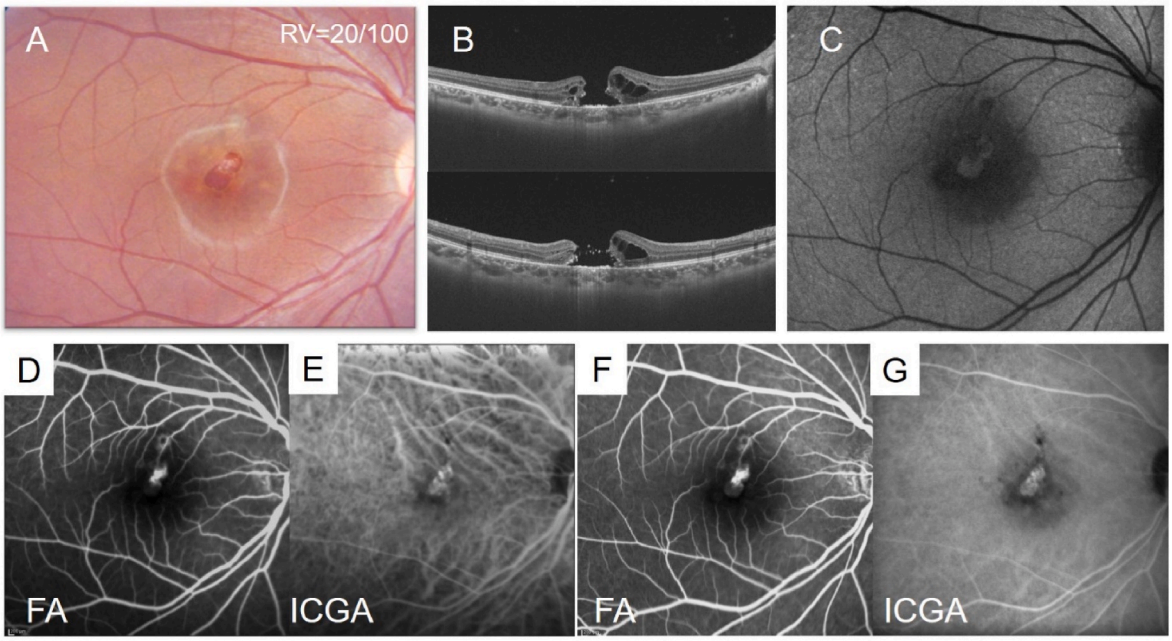

Fig. 3. (A) At the first visit to Nagoya City University Hospital, a fundus image of the right eye shows an irregular macular hole. (B) Optical coherence tomography of the right eye shows a full-thickness macular hole with intraretinal cystic changes. (C) Fundus autofluorescence imaging shows hyperfluorescence consistent with the macular hole and low fluorescence consistent with the injured region superior to the fovea. Fluorescein/indocyanine green fluorescein fundus angiography (FA/ICGA) in (D) early-phase FA and (E) ICGA show hyperfluorescence consistent with the macular hole, and no fluorescence leakage in late-phase (F) FA and (G) ICGA. A hypoautofluorescent area has hypofluorescence on ICGA. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

patient is a nurse, and the accident occurred inside the hospital. Thus, great care should be taken when dealing with a laser device for purposes other than research and experimentation. Generally, the rate of spontaneous closure of traumatic macular holes is relatively high especially in patients under the age of 24 years with a macular hole 0.2 disc diameter or less in size and uncomplicated by other severe ocular injuries.[4] However spontaneous closure of a macular hole is difficult with YAG laser injuries. The Nd:YAG laser, especially the Q-switched mode, allows for a shorter delivery interval in the nanosecond range. As high laser energy is compressed into a very short time and a small spot, it is sufficient to cause optical destruction of the target tissues.[5] This mechanism of the Nd:YAG laser may lead to severe retinal and choroidal damage that often is associated with retinal and choroidal vascular disruption and consequent vitreous, intraretinal, or subretinal hemorrhage.[6] In cases of severe Nd:YAG laser-induced injuries, the damage could extend to the choroidal level and can impair the choroidal circulation.[7] These severe tissue injuries may make spontaneous closure of a macular hole difficult.

Fernandez et al.[8] reviewed 15 eyes of macular holes secondary to accidental Nd:YAG laser exposure. Twelve of 15 eyes were observed, four of which achieved spontaneous closure. The other three eyes were surgically repaired and all holes closed successfully. Stein et al.[9]

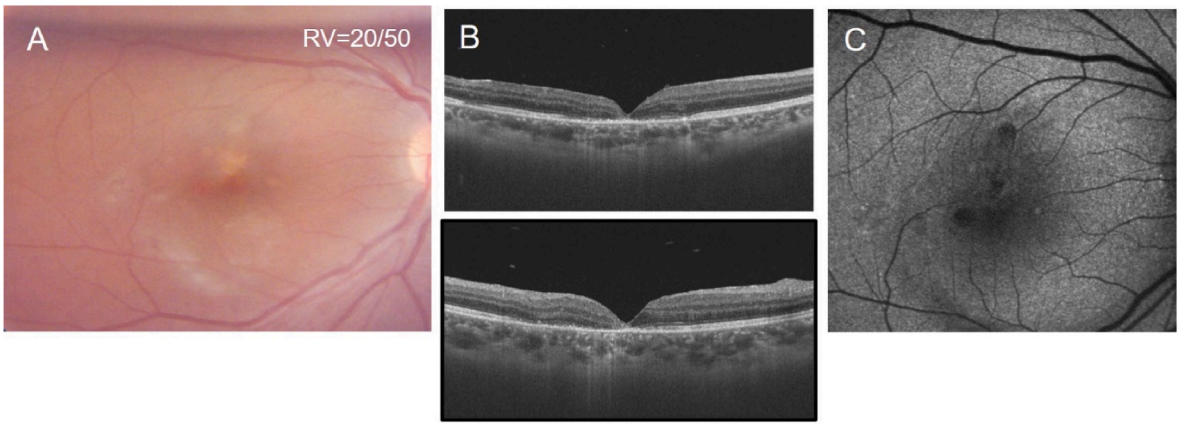

Fig. 4. Ten days postoperatively, (A) fundus and (B) optical coherence tomography images show closure of the macular hole. Retinal edema and retinal detachment are negligible. (C) A fundus autofluorescence image shows foveal and extrafoveal hypofluorescence regions.

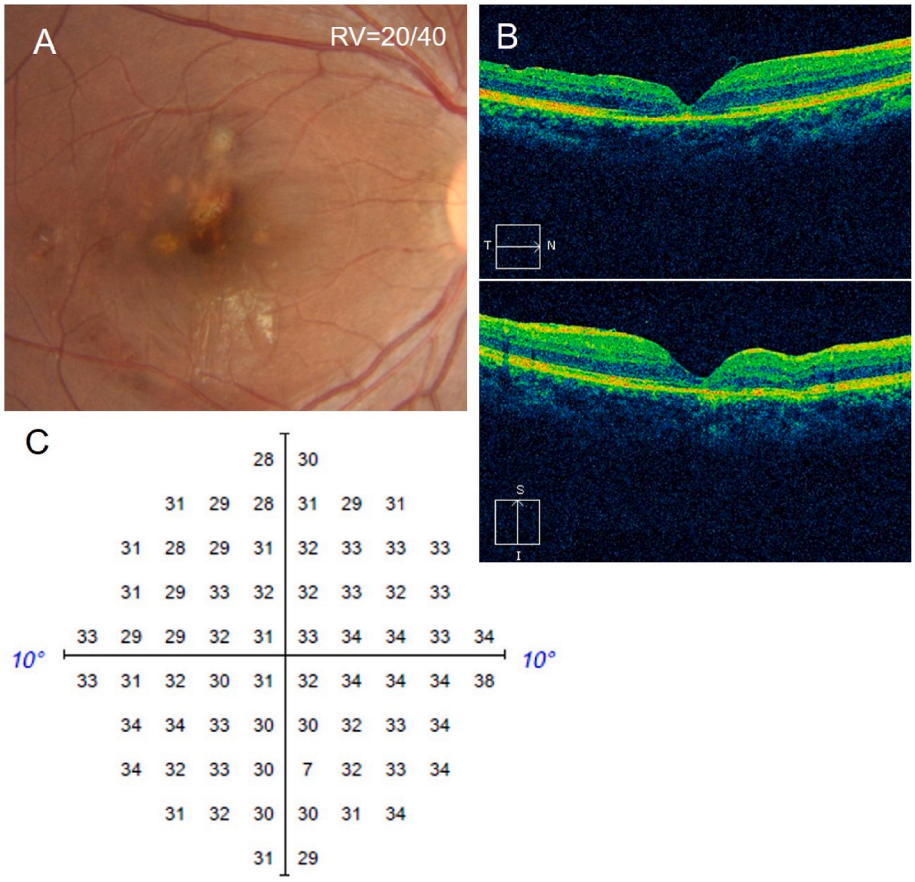

Fig. 5. Eight weeks postoperatively, (A) fundus and (B) optical coherence tomography images show sustained closure of the macular hole with partial atrophy of the retina and the retinal pigment epithelium. (C) While Humphrey field analyzer 10-2 perimetry shows that the retinal sensitivity in the injury region has mostly improved, a hypofluorescent region superior to the fovea on indocyanine green imaging remains less sensitive. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

reviewed eight eyes that underwent surgical repair of macular holes secondary to accidental Nd:YAG laser exposure and reported that all eyes achieved anatomic closure. The duration from the onset of a macular hole to the initial surgery differed between the two groups with a range of 10 days to 2 months in cases with the good final BCVA[8,10–12] and a range of 4–5 months in cases with a poor final BCVA.

In the current case, a whitened retina, SRD, destruction of the retinal structure, and obscuration of the ellipsoid zone were observed at the fovea, suggesting serious retinal damage. As previous reports suggested[2,8,9] that spontaneous closure of the macular hole was unlikely, early surgical repair was performed, resulting in a good visual outcome.

Although this is an unfortunate case in which a nurse injured her eye while working with a Q-switched Nd:YAG laser, other reports of traumatic macular holes caused by cosmetic YAG lasers have been published.[2,13,14] Table 1 shows the summary of FTMHs caused by Nd:YAG laser used in cosmetic surgery. The preoperative VAs of five injured eyes decreased significantly, ranging from 20/200 to 20/666, and there was damage to the ellipsoid zone and external limiting membrane and injury to the RPE and choroid in all eyes. In all five cases, the macular hole was closed by vitrectomy. Gao et al.[13] and Obana[2] reported poor postoperative VAs of 20/200 and 20/2000, respectively. Vitreous hemorrhages developed in these two cases immediately after the injury. The prognosis for VA may be poor despite macular hole closure if the laser impact is sufficiently severe to cause vitreous hemorrhage.

Table 1
Cases of full-thickness macular holes caused by Nd:YAG laser use during cosmetic surgery.

Author, study year	Patient age (years), gender, eye	Wave-length	Energy (mJ)	BCVA before surgery	Size of hole before surgery (μm)	Time to initial surgery (months)	Vitreous hemorrhage present	Surrounding macular hole CME	Surgical ILM peeled or inverted	Dye used	Gas	Repeat PPV	Outcome	Final BCVA	Follow-up after PPV (months)
Current case	Unknown	1064 nm	N/A	20/100	600	1	No	Yes	Inverted	ICG	SF6	No	Closure	20/25	9
Gao et al.; 2007	36, male; OD	Unknown	500	20/200	700	5	Yes	Yes	Peeled	N/A	C2F6	No	Closure	20/200	13
Obana et al.; 2019	38, female; OD	1064 nm	2.7	20/666	653	1	Yes	Yes	Inverted	No	Air	Yes	Closure	20/2000	11
Qi et al.; 2017	21, female; OS	1064 nm	Unknown	20/200	646	2	No	Yes	Peeled	No	C3F8	No	Closure	20/20	36
	38, female; OS	1064 nm	Unknown	20/100	503	2	No	Yes	Peeled	No	C2F6	No	Closure	20/30	3

BCVA, best-corrected visual acuity; CME, cystoid macular edema; ICG, indocyanine green; ILM, internal limiting membrane; N/A, not available; OCT, optical coherence tomography; OD, right eye; OS, left eye; SF6, sulfur hexafluoride; C2F6, Hexafluoroethane.

In the current case, the accident occurred in preparation for a cosmetic dermatology procedure during which an Nd:YAG laser device is commonly used in clinical practice. Other cases have been reported during cosmetic surgery. Obana[2] reported that a 38-year-old female nurse was training for laser toning using Nd:YAG laser and an accidental macular hole occurred in her right eye when she was applying laser light to the training paper contained in the clear plastic film. The macular hole was closed by vitrectomy, but the VA deteriorated to 20/2000. She also was not wearing protective goggles. In the current case and that of Obana,[2] the accidents occurred during practice. The use of the plastic film, which has high light reflectance and the absence of protective goggles may have led to the development of the macular holes. Unlike specialists, who deal with laser in the laboratory, users in the medical field do not always have detailed knowledge of lasers. Therefore, when dealing with lasers, it is necessary to have sufficient education about the associated risks.

Recently, YAG laser vitreolysis has been performed to treat symptomatic vitreous opacity.[15,16] However, complications of Nd:YAG laser vitreolysis have been reported such as cataract, glaucoma,[17] posterior capsule defects requiring cataract surgery,[18] rhegmatogenous retinal detachment,[19] and retinal hemorrhage.[20] In addition, since YAG laser vitreolysis is a technique that irradiates very close to the retina, especially the macula, it is important for clinicians to be fully aware of its risk vs benefit profile and to avoid injury to the retina by accidental irradiation.

In conclusion, we experienced a case in which a nurse was exposed to an Nd:YAG laser during work that resulted in development of a traumatic macular hole. She was not wearing a protective goggles during the incident. Vitrectomy using the inverted ILM flap technique was performed within one month of the onset of the FTHM, resulting in closure of the hole and relatively good visual acuity. It should be emphasized that it is necessary to wear protective goggles whenever using a laser device in any situation.

Patient consent

Informed consent was obtained from the patient.

Disclosures

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Declaration of competing interest

The authors declare that they have no conflicts of interest associated with this report.

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