

Laser-induced ocular injury: a narrative review

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Abstract

There is an increasing trend of reported laser-induced ocular injury. We aimed to review the literature on the basic principles of laser, clinical management and safety precaution of laser-induced ocular injury. A literature search on the PubMed database was conducted to include articles dated up to April 2020. One example case of laser-induced ocular injury is provided. Clinical presentation of laser-induced ocular injury is variable. The clinical features can be transient and subtle. Appropriate investigations are useful to establish a diagnosis and to evaluate the severity of the injury. Laser-induced ocular injury most commonly involves the macula, which can be complicated by intraocular haemorrhage, macular hole, epiretinal membrane, and choroidal neovascularization. There are currently no evidence-based or well-recognized treatments for laser-induced retinopathy. Surgical intervention might be considered if there is significant intraocular hemorrhage or macular hole. Laser-induced ocular injury may cause permanent visual sequelae and functional disability. Diagnosis of an eye injury should be supported by objective clinical findings and/or appropriate investigations. As medical and surgical treatment options are currently limited, the key to combat laser ocular injuries lies in prevention and awareness of the general public should be reinforced.

Key words: Eye injuries; Lasers; Safety

Introduction

Laser has been widely used for occupational, military, medical, and cosmetic purposes.¹ There is an increasing trend of laser-related ocular injuries secondary to high-powered handheld laser devices.² Lack of awareness regarding the sight-threatening hazards of these devices may lead to inadvertent or deliberate laser use.³ Laser-induced ocular injury in children is a major public health issue.⁴ Aircraft risks attributable to laser strikes have been reported.⁵ Public awareness regarding the hazardous effect of laser should be reinforced.⁶ The aim of this study is to review the literature on the investigation and management of laser-induced ocular injury, as well as safety precautions that can be taken.

Example case

In January 2020, a 14-year-old boy presented to an eye clinic 4 days after having a sudden drop of left eye vision while playing with a laser pointer at home. At presentation, visual acuity of the right eye and left eye was 20/25 and 20/60, respectively. Fundal examination of his left eye revealed cystoid changes at the fovea, but there was no anterior segment injury or retinal or vitreous hemorrhage. The involved laser pointer was not available for verification of its power and specification. Optical coherence tomography (OCT) of the left eye macula showed subfoveal cystoid change with disruption of inner segment–outer segment junction (**Figure 1a**). The retinal pigment epithelium (RPE) layer was intact. The patient was treated with topical 1% prednisolone acetate four times per day and 0.1% nepafenac three times per day for one week. The visual acuity of his left eye gradually improved to 20/30 at 3 weeks. The cystoid changes at the macula was subsequently resolved. OCT of the left eye macula showed resolution of cystoid changes, re-establishment of inner segment–outer segment junction continuity and foveal depression (**Figure 1b**). There was no discernible anatomical

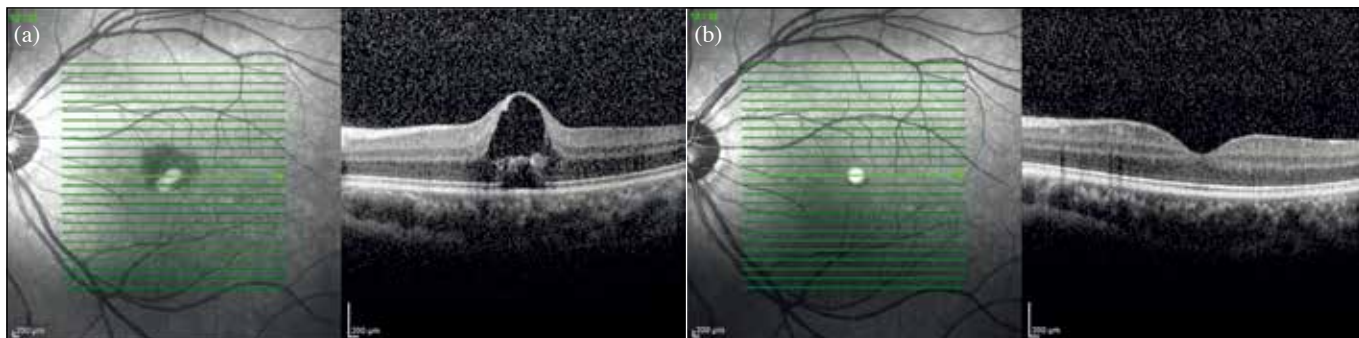


Figure 1. Optical coherence tomography of the left eye fovea (a) at 4 days after the laser-induced injury showing cystoid change at fovea with disruption of inner segment–outer segment junction, an intact retinal pigment epithelium, and a central macular thickness of 518 μm. (b) at 3 weeks after injury showing resolution of cystoid changes, re-establishment of inner segment–outer segment junction continuity and foveal depression.

Table 1. Classification of laser according to the output power ^{8,9}				
Class of laser	Output power, mW	Risk	Precaution	Example
1/1M	<0.4	Considered not hazardous during normal operation unless viewed through specific optical instrument	Exempt from control measures or surveillance other than to prevent potentially hazardous optically aided viewing	Laser printers, CD and DVD players
2/2M	<1	Low risk: safe for brief momentary exposure; may be harmful with prolonged direct viewing or viewed with optical aids	Eye protection afforded by the aversion response; prevent viewing through hazardous optical instruments	Barcode scanners
3R	<5	Moderate risk: potentially hazardous under direct and specular reflection viewing if eye is focused and stable	Avoid direct beam viewing; wear laser protective eyewear; prevent unintentional specular reflections	Laser pointers for presentation and recreational use
3B	<500	Moderate risk: potentially hazardous under direct and specular reflection viewing	As class 3R; designated laser controlled area and laser safety officer required under Hospital Authority regulations	Majority of industrial, military and medical lasers
4	>500	High risk: Hazardous to the eye or skin from direct beam; diffuse reflection or fire hazard; laser generated air contaminants; plasma radiation	As class 3R; protective clothing required if maximum permissible exposure for the skin is exceeded	

abnormality detected. Although outer retinal damages are common in laser-related injury, intraretinal fluid with cystoid change is an uncommon presentation.⁷

Literature search

The PubMed, EMBASE, and Web of Science databases were searched for articles published between 1998 and May 2020 using keywords: ‘laser’ and ‘eye injury’ and ‘ocular injury’ or ‘laser eye injury’ or ‘laser ocular injury’ or ‘laser retinal injury’ or ‘laser macular injury’ or ‘laser induced maculopathy’ or ‘laser induced retinopathy’ or ‘laser pointer’. Of 4969 articles yielded, 4637 duplicated or irrelevant articles were excluded and 332 articles were included. References in the included articles were reviewed to identify additional relevant studies. Of the 332 articles, those written in languages other than English were excluded, as were statements, editorials, and letters to the editor. Eventually, 157 articles were reviewed. Internationally adopted guidelines and safety manuals regarding laser use were referenced.

Classification and application of laser

A laser is a monochromatic, coherent, and collimated light beam that is polarized, minimally divergent, and has a single frequency. Lasers are classified by the maximum output power into four classes (**Table 1**): class 1 is safe under all conditions of normal use, whereas class 4 is hazardous to the eye or skin and may pose a diffuse reflection or fire hazard.^{8,9} Classes 3 and 4 laser are commonly applied in ophthalmological equipment for the treatment of various ocular conditions such as glaucoma and retinal diseases.

Laser pointers are widely used in educational and business presentations, amateur astronomy, construction work, and entertainment purpose. They are available in various colors on the visible light spectrum, with the most common being green (532 nm) or red (650-670 nm) diode laser.^{10,11} Most consumer laser pointers are categorized as class 3R with output power of <5 mW, which is relatively safe to human eyes upon accidental viewing due to limitation of exposure

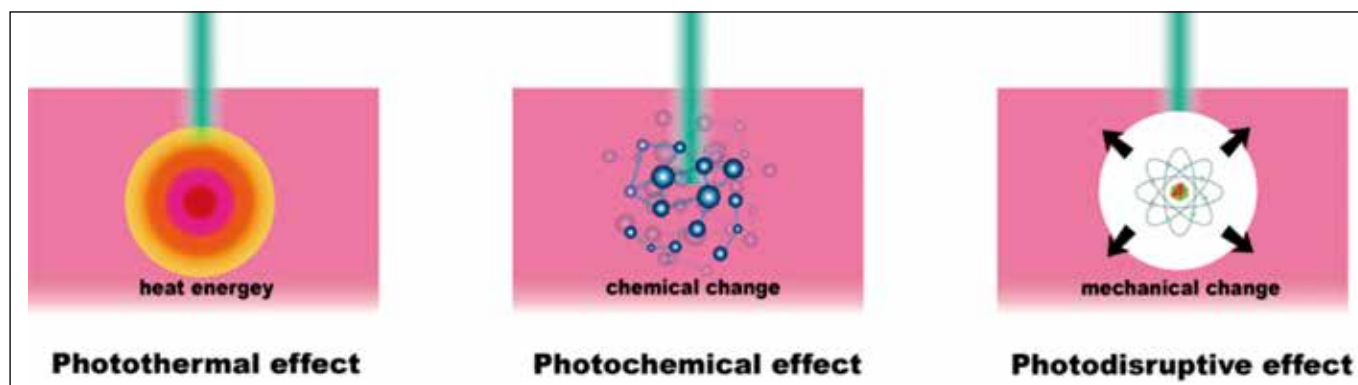


Figure 2. Photothermal effect involves a local temperature rise owing to absorption of laser energy, leading to protein denaturation and tissue damage. Photochemical effect occurs when laser energy induces chemical reactions in the absorbing molecules without significant build-up of heat. Photodisruptive effect happens when rapidly absorbed laser energy causes disintegration of tissue into plasma, eventually leading to mechanical disruption of surrounding tissues.

time by the blink reflex and aversion response. However, mislabeling of output power may impose hidden danger. In a test of 122 commercial laser pointers, 89.7% of green pointers and 44.4% of red pointers labeled as class 3R devices had a power output of >5 mW,¹⁰ and 52.4% of the tested devices exceeded the legal limit by at least a factor of 2 at one or more wavelengths. In Hong Kong, there are no regulations on the usage or purchase of laser pointers. As for sellers, it is an offence to supply or manufacture goods unless it complies with the safety requirements under the Consumer Goods Safety Ordinance.¹² In many other jurisdictions, the power of laser pointer available to the general public is restricted to <5 mW.¹³

Mechanisms of laser-induced eye injury

Laser-tissue interaction in the eye involves three mechanisms: photothermal, photochemical, and photodisruptive (**Figure 2**). Photothermal interaction occurs when laser energy is absorbed by a chromophore, such that the rate of heat energy production is greater than the rate of energy dissipation, leading to local temperature rise.^{1,14,15} An increase in temperature causes protein denaturation and coagulation, resulting in cell death followed by tissue necrosis and scarring.¹⁵ Photochemical interaction occurs when laser energy is delivered at relatively low power and long pulses and induces chemical reactions in the absorbing molecules without significant build-up of heat.^{1,16} Photodisruptive interaction occurs when energy is absorbed rapidly at a pulse duration of picoseconds to nanoseconds. A rapid increase in temperature causes stripping of electrons from atoms and disintegration of tissue into plasma.¹⁴ In combination with the ensuing vaporization of water molecules, a compressive pressure pulse is generated, mechanically disrupting the surrounding tissues.^{1,14}

Effects of laser to ocular tissue

The tissue involved in laser-induced ocular injury depends on the optical property of ocular structures and the wavelength of the laser. Laser-induced injury to ocular structures other than the retina is uncommon, as they are optically transparent in the visible and near-infrared spectrum. Lasers in these

wavelengths are transmitted by the optical media of the eye and focused onto the retina by its refractive components (cornea, aqueous humor, lens, vitreous humor).¹⁷ The refractive power of the cornea and lens can produce retinal irradiance of up to 10^5 times greater than corneal irradiance.¹⁸ With the use of binoculars or other magnifying optics, the increase in irradiance may be more than a million fold.¹ This makes the retina highly susceptible to laser injury. Melanin pigment, which is abundant in the retinal pigment epithelium, absorbs laser energy and leads to a localized temperature elevation or even a plasma formation.¹⁸ Continuous-wave lasers such as argon laser and lasers from commercial laser pointers can cause retinal injury mainly by photothermal mechanism, whereas Q-switched lasers such as Nd:YAG laser can cause retinal injury by photodisruptive effect. Q-switched laser injury tends to be more dangerous because they can produce very high power concentration at a localized site.^{1,14} In contrast, laser in the ultraviolet spectrum is rapidly absorbed by the cornea, causing corneal injury by the photochemical mechanism.^{1,19} One such example is the excimer laser (with wavelength of 193 nm) in keratorefractive surgeries. Laser with longer wavelength, such as the mid-infrared CO₂ laser, is readily absorbed by water molecules in any tissue. It does not penetrate deeper than 100 μ m in the cornea but may result in corneal and scleral injury or injury of the external adnexa by the photothermal mechanism.^{1,20}

Clinical presentation of laser-induced ocular injury

Clinical presentations of ocular laser injury vary, depending on the type of laser, duration of exposure, and the method of administration (**Table 2**).⁴ The retina (the macula in particular) is most susceptible to laser injuries.^{2,21,22} The wide availability of handheld laser devices is associated with an increased incidence of pediatric laser-induced ocular injury,^{2,22,23} accounting for 70% to 80% of reported cases.^{4,22} Handheld laser devices have been reported to be associated with playing with laser,²¹ accidental injury inflicted by others,²¹ self-inflicted injury,²⁴ intentional self-harm,²⁵ and assault.²⁶ Other mechanisms of injury include occupational,²⁷ recreational,²⁸ medical,²⁹⁻³⁶ military,^{37,38} and air flight exposure to laser.³⁹

Table 2. Summary of laser-induced ocular injury in the literature

Types of injury	Clinical signs	Investigation	Treatment	Mechanisms of injury
Eyelid injury ⁴²	Lid retraction, lagophthalmos	Photography of external adnexa	Topical lubricant, punctal plug	Handheld laser devices: playing with laser; ²¹ accidental injury inflicted by other; ²¹ self-inflicted injury; ²⁴ intentional self-harm. ²⁵ assault ²⁶
Corneal injury ^{43,63}	Bullous keratopathy, intrastromal bleeding, corneal burn with scar, corneal ulcer, corneal perforation, exposure keratopathy	Slit-lamp photography, corneal sensation, tear break-up time, basal secretion test	Topical antibiotics, topical prednisolone, ocular patching, contact lens, corneal transplant	
Iris / uveal tissue injury ^{32,35,51,87}	Iris atrophy, corectopia, posterior synechiae, atonic pupil, uveitis	Slit-lamp photography	Topical and oral prednisolone, cycloplegic eyedrop, pilocarpine (for atonic pupil), subtenon triamcinolone	Medical laser devices: cosmetic laser procedure, ⁴³ laser removal of skin lesion, ³² laser epilation of eyelid ³⁰ / eyebrow, ^{29,51} ophthalmic laser application ^{49,50}
Lens injury ^{30,51,52}	Cataract	Slit-lamp photography	Cataract surgery	Occupational exposure to laser ²⁷ Air flight exposure to laser ³⁹ Recreational exposure to laser ²⁸ Military laser accident ^{37,38}
Elevated intraocular pressure ³⁶	Corneal edema	Goldmann applanation tonometry	Pressure-lowering agents	
Visual field defect ⁶²	Scotoma, peripheral visual field loss	Automated perimetry, microperimetry	-	
Retinal injury ^{28,48,88}	Hypo- or hyper-pigmentation, yellow submacular lesion, vitreous/preretinal/subretinal hemorrhage, retinal pigment epithelium changes, chorioretinal scar, epiretinal membrane, full-thickness macular hole, choroidal neovascularization	Fundus photography (color, infrared or autofluorescence), Amsler grid, fluorescein angiography, optical coherence tomography, optical coherence tomography angiography, electroretinography	Topical or oral prednisolone, intravenous methylprednisolone, anti-vascular endothelial growth factors, Nd:YAG laser hyaloidotomy, pars plana vitrectomy +/- internal limiting membrane peeling +/- intraocular gas tamponade	

Laser is commonly used in aesthetic and dermatological medicine, including treatment of pigmented or vascular lesions, hair removal, and facial rejuvenation.^{40,41} The eyelid skin is thin and lacks subcutaneous fat, leaving the globe vulnerable to both anterior or posterior segment injury from laser energy absorption.^{35,41} Laser skin resurfacing has been reported to cause thermal injury of the eyelid and corneal damage.^{42,43} Anterior segment injury from laser-assisted eyebrow epilation is commonly reported.^{44,45}

Occupational laser-induced injuries are primarily associated with pulsed lasers such as Nd:YAG laser in industrial or laboratory settings.¹ Recreational exposure to laser in laser light show has been reported to cause retinal injury,^{28,46} as has accidental laser exposure in military exercises, actual combat,³⁸ and civilian airlight.^{1,5}

Patients can usually recall a history of exposure to laser devices. However, elusive exposure history and delayed clinical presentation are not uncommon among pediatric patients.^{4,22} Sudden onset of unilaterally decreased vision is the typical presentation of visually significant retinal laser injury.⁴⁷ The severity of visual loss depends on the proximity of the laser impact site to the fovea, the extent of chorioretinal disruption, and the amount of intraocular bleeding.^{4,21,47,48} Apart from the posterior segment, laser may cause injury of the external adnexa and the anterior segment (**Table 2**). Common symptoms include eye pain, temporary loss of vision, and conjunctival erythema.⁴¹ Mechanisms of injury involving external adnexa and anterior segments tend to

differ from those of retinal injury and are often associated with dermatological laser procedure⁴³ and ophthalmic laser application.^{49,50} Anterior segment injuries are more commonly induced by lasers of longer wavelength such as Alexandrite laser (755 nm) and diode laser (810 nm) used in epilation of eyebrow^{30,36} and carbon dioxide laser used in skin resurfacing.^{42,43} Alexandrite laser and diode laser are readily absorbed by the heavily pigmented iris, causing iris atrophy and corectopia.^{30,32,34-36,51} They can result in normotensive or hypertensive anterior uveitis, leading to posterior synechiae formation.³¹⁻³⁶ Carbon dioxide laser may lead to exposure keratopathy secondary to lower lid retraction.⁴² Cataract formation^{30,51} and cataract in infants treated with argon laser photocoagulation for threshold retinopathy of prematurity have been reported.⁵² Although the extent of corneal injury associated with laser procedures is often mild,⁵³ severe corneal damage with bullous keratopathy or corneal perforation⁵⁴ necessitating penetrating keratoplasty⁴³ has been reported.

In a systematic review on retinal injury secondary to laser pointer exposure,⁷ 55% of patients have visual acuity of less than 20/40 at presentation, around 9% of patients have 20/20 or better, and 5% of patient had visual acuity of finger counting. The most common fundoscopic finding was pigmentary changes with hypo- or hyperpigmentation (53%), followed by yellow foveal lesions (33%), macular hole (23%), and hemorrhage (14%). Although a large proportion of laser-induced ocular injury improves spontaneously, medical and/or surgical intervention may be required for complications such as subretinal, intraretinal, subhyaloid, and preretinal

hemorrhage, full-thickness macular hole, and epiretinal membrane and choroidal neovascularization.^{7,21,22,28,48,55-57} One case report described rod and cone cells dysfunction leading to diffuse peripheral visual field defect following a diode laser injury.³⁴

Differential diagnoses of laser-induced retinal injury include retinal dystrophies (eg, Best disease and Stargardt disease) and inflammatory and ischemic retinopathies.^{4,7} Laser-induced injuries rarely progress following acute damage, but inherited retinal diseases are characterized by bilateral involvement and gradual progression. Multimodal investigations including sequential OCT and electrophysiology tests are occasionally indicated.^{4,58} Some cases of laser-induced retinal injury in pediatric patients have been mistakenly referred to the genetic service for possible inherited retinal disease.⁵⁸ Behavioral or psychiatric conditions have been reported to be associated with self-inflicted laser insults.^{23,59} Attention deficit hyperactivity disorder and autism spectrum disorders are proposed to increase the risk of such injuries.²³ Psychiatric conditions should be recognized and collaboration with mental health experts may be necessary.²³

Investigation

Laser-induced ocular injury may have considerable legal, financial, and medical consequences.⁶⁰ Accurate diagnosis requires detailed history taking and prompt ophthalmic assessment, as clinical signs are often transient and subtle.⁶¹ If the mechanism of laser exposure and clinical examination findings are ambiguous, further investigations may be used to confirm ocular insult secondary to the alleged accident. Documentation of best-corrected visual acuity is essential. Photographic documentation of external adnexa, anterior segment, or fundus is invaluable to record clinically apparent pathologies following laser-induced injury. Slit-lamp examination, Goldmann applanation tonometry, corneal sensation, tear break-up time, and basal secretion test can be performed if the anterior segment is involved. Infrared photography and fundus autofluorescence may help to characterize the retinal lesion.⁶¹ Amsler grid testing shows subjective functional deficits including metamorphopsia and scotoma.⁷

Fluorescein angiography of acute photocoagulation laser-induced injuries typically produces a hyperfluorescent ring with a hypofluorescent center.⁶⁰ In cases with secondary vitreous or chorioretinal hemorrhages, a hypofluorescent area secondary to overlying blockage may be observed.²⁸ As the hemorrhage resolves and RPE atrophy ensues, a hyperfluorescent window defect may develop. Late retinal fibrosis or chorioretinal scarring give rise to hyperfluorescence owing to staining. Choroidal neovascularization can also be demonstrated with active leakage.⁴⁸ Incidental findings of minor angiographic abnormalities are not uncommon in normal individuals and should be interpreted with caution before attributing it to a laser-induced injury.⁶²

OCT of the macula may demonstrate a spectrum of features including RPE change, focal inner segment–outer segment

junction disruption, retinal edema and cystoid changes, hemorrhages, and macular hole.⁴ The outer retina often demonstrates localized hyperreflectivity, accompanied by persistent disruption of the outer retinal layers.⁷ OCT angiography is useful to detect choroidal ischemia or choroidal neovascularization.⁴⁸ Based on OCT features, a classification of laser-induced retinal injuries has been proposed to quantify retinal laser energy absorption and RPE damage.²² However, it is difficult to correlate the severity of injury based on OCT features with the degree of visual impairment or prognosis.^{4,22} Electroretinography can be used to assess possible rod and cone cells dysfunction following laser-induced injury.³⁴

Functionally, automated perimetry and microperimetry may be used to document visual field defects or reduced macular sensitivity.⁷ Follow-up examinations may be arranged to monitor visual field deficits, which may spontaneously improve or remain static.⁶¹

Treatment

There is no evidence-based consensus on treatment for laser-induced ocular injury. In general, visual symptoms and anatomical changes tend to improve with time, although permanent vision loss and scotoma may persist in some patients.⁴ Watchful waiting may be a reasonable option for relatively mild cases, especially for injuries of the extrafoveal or peripheral retina.^{4,7}

Treatment is largely determined by the extent of injury and includes medical and/or surgical management. Superficial lesions to the corneal epithelium can be treated with topical antibiotics, patching, or contact lenses.⁶³ Lid retraction and lagophthalmos are managed with topical lubricants or punctal plug.⁴² Cycloplegic eyedrops, topical or oral steroids at varying treatment lengths are helpful to reduce the damaging inflammatory response to injury.³⁵ Subtenon triamcinolone has been used to manage severe anterior uveitis.³⁵ Pressure-lowering agents can be used for increased intraocular pressure, and pilocarpine can be used to manage pupil distortion after laser-induced injury.⁵¹

Topical or systemic corticosteroids have been used to treat laser-induced retinopathy in the belief that they reduce production of inflammatory cytokines, limit neutrophil infiltration, and reduce retinal photoreceptor damage and glial scar formation.^{1,47,64-66} Systemic methylprednisolone and indomethacin in animal study improve photoreceptor survival after laser-induced injury.^{4,48,67,68} However, negative effects of methylprednisolone in animal model with laser-induced retinal injury have also been reported.⁶⁹ The clinical efficacy of corticosteroids in humans is based on case reports only.^{1,11,22,28,70-72} The therapeutic effect of medications is often confounded by the natural course of ocular injury.^{22,27,73,74} Overall, the role of systemic corticosteroid and non-steroidal anti-inflammatory agents in laser-induced retinopathy remains inconclusive.

Various medications including oral lutein, deferoxamine, and human recombinant fibroblast growth factors have been

used in the treatment of laser-induced retinal injury.^{4,75,76} However, results vary widely and are largely experimental. Anti-vascular endothelial growth factors may be of value if secondary choroidal neovascularization develops.⁴⁸ There is limited evidence on the indication, dosage, and therapeutic window of medical therapy for laser-induced retinopathy, and the usage of various medical therapies remains controversial.

Severe corneal injury leading to bullous keratopathy or corneal opacity with vision loss may require surgical intervention such as corneal transplantation.^{43,63} Mild cataracts can be managed conservatively, whereas surgery is considered for visually significant cataracts.^{51,52} Surgical intervention may be considered if there is significant intraocular hemorrhage. It is particularly beneficial in cases that require prompt restoration of vision.¹ As pre-retinal blood may induce fibrosis with formation of chorioretinal scar, epiretinal membrane or secondary macular hole,^{21,77} pars plana vitrectomy may be used for vitreous or pre-retinal hemorrhage that do not clear spontaneously within a short period.⁵⁷ Nd:YAG laser hyaloidotomy may be an option for cases of subhyaloid or sub-internal limiting membrane hemorrhages.^{21,78,79} Laser-induced macular hole can occur immediately or several days after injury.^{21,80,81} Spontaneous closure of macular hole has been reported for smaller macular holes (<250 μm),⁸² and observation can be considered.^{83,84} Macular holes of >250 μm are indicated for surgical intervention to prevent further anatomical and functional deterioration.^{84,85} Pars plana vitrectomy with internal limiting membrane peeling and intraocular gas tamponade is used to treat eyes with full-thickness macular hole secondary to laser injury.^{21,84,85}

Prognosis

The prognosis for laser-induced retinal injuries is generally favorable. Laser-induced injury involving external adnexa and anterior segment generally have good outcome with visual acuity of 20/40 or better.³² In a review of laser-induced retinal injury, 55% of eyes recovered to visual acuity of 20/25 or better within a few months and 36% recovered to visual acuity of 20/100 to 20/30.¹ Nevertheless, a large proportion of patients have visual acuity worse than 20/200, especially those in younger age-groups.^{4,23} In general, the further away the lesion is from the fovea, the better the recovery. However, development of late complications may adversely affect the outcome. Chorioretinal scarring is the most common complication.^{4,48} Other sequelae including macular hole, macular cyst, epiretinal membrane formation, and choroidal neovascularization can lead to unfavorable visual outcome.^{4,7,48,84}

Preventive measures

In Hong Kong, there is no statutory regulation on the purchase or usage of laser-incorporated products even for high-energy output classes 3 or 4 lasers.⁶² Hand-held laser pointers are commonly used for educational and recreational purposes, giving rise to an increasing incidence of laser-induced ocular injury.^{28,56} Public education on the potential harmful effects of lasers should be reinforced in order to prevent accidental

or deliberate laser injuries.² Furthermore, manufacturers and sellers of laser devices should affix proper explanatory and warning labels to laser products.⁸⁶

In the occupational setting, it is important to ensure that the environment is optimal for the safe operation of laser machines, and all staff are compliant to laser safety protocols. Covering all reflective surfaces and ensuring the room door is locked while a laser is in use are simple but effective measures to minimize inadvertent injuries. Because lasers are monochromatic in nature, wavelength-specific filters are effective in blocking specific laser beams while allowing sufficient light of other wavelengths to be transmitted.¹ These filters are used in safety goggles and operative microscopes to protect operators from laser exposure. Safety goggles with correct corresponding wavelength should be used when operating or switching between laser machines. For patients receiving therapeutic laser treatments, protective eye wear should be used when appropriate.^{87,88}

Conclusion

Laser-induced ocular injury may cause permanent visual sequelae and functional disability. Making an accurate diagnosis may have potential medicolegal consequences, and thus it should be supported by clinical findings and/or appropriate investigations. Timely assessment is important, as clinical signs may be temporary and subtle. Prevention and protection of laser-induced ocular injuries is more important than treatment. Awareness of the potential hazardous effects of laser use should be reinforced among healthcare providers and the general public.

Author contributions

Concept or design: EW, FL
 Acquisition of data: EW, AL
 Analysis or interpretation of data: EW, AL, FL
 Drafting of the article: EW, AL, FL
 Critical revision for important intellectual content: RL, FL

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have no conflicts of interest to disclose.

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Ethics approval

The patient was treated in accordance with the Declaration of Helsinki. The patient provided written informed consent for treatments and procedures.

References

- Barkana Y, Belkin M. Laser eye injuries. *Surv Ophthalmol* 2000;44:459-78. [Crossref](#)
- Torp-Pedersen T, Welinder L, Justesen B, et al. Laser pointer maculopathy – on the rise? *Acta Ophthalmol* 2018;96:749-54. [Crossref](#)
- Altwijiri R, Alsuliman SA, Alanazi L, et al. Knowledge and attitude towards hazardous effects of laser pointers among attendees of football matches in Riyadh, Saudi Arabia. *Saudi J Ophthalmol* 2020. [Crossref](#)
- Neffendorf JE, Hildebrand GD, Downes SM. Handheld laser devices and laser-induced retinopathy (LIR) in children: an overview of the literature. *Eye (Lond)* 2019;33:1203-14. [Crossref](#)
- Nakagawara VB, Montgomery RW. Laser pointers and aviation safety. *Aviat Space Environ Med* 2000;71:1060-2.
- Alsulaiman SM, Al-Qahtani A, Mousa A, Ghazi NG. Laser pointers: how much does the general medical community know? *Graefes Arch Clin Exp Ophthalmol* 2017;255:635-6. [Crossref](#)
- Birtel J, Harmening WM, Krohne TU, et al. Retinal injury following laser pointer exposure. *Dtsch Arztebl Int* 2017;114:831-7. [Crossref](#)
- American National Standards Institute. American National Standard for Safe Use of Lasers, ANSI Z136.1. 2007.
- BSEN 60825: 992. Radiation safety of laser products, equipment, classification, requirements and users guide. British Standards Institution; 1992.
- Hadler J, Tobares EL, Dowell M. Random testing reveals excessive power in commercial laser pointers. *J Laser Appl* 2013;10:2351/1.4798455.
- Xu K, Chin EK, Quiram PA, Davies JB, Parke DW 3rd, Almeida DR. Retinal injury secondary to laser pointers in pediatric patients. *Pediatrics* 2016;138:e20161188. [Crossref](#)
- Retail shops fined for supplying unsafe laser pointers. Customs and Excise Department https://www.customs.gov.hk/en/publication_press/press/index_id_1583.html. Accessed 15 May 2020.
- Safety of Laser Products - Part 1: Equipment Classification and Requirements. 2nd ed. International Electrotechnical Commission; 2007.
- Mainster MA, Sliney DH, Belcher CD 3rd, Buzney SM. Laser photodisruptors. Damage mechanisms, instrument design and safety. *Ophthalmology* 1983;90:973-91. [Crossref](#)
- Marshall J. Thermal and mechanical mechanisms in laser damage to the retina. *Invest Ophthalmol* 1970;9:97-115.
- Ham WT Jr, Ruffolo JJ Jr, Mueller HA, Guerry D 3rd. The nature of retinal radiation damage: dependence on wavelength, power level and exposure time. *Vision Res* 1980;20:1105-11. [Crossref](#)
- Boettner EA, Wolter JR. Transmission of the ocular media. *Invest Ophthalmol Vis Sci* 1962;1:776-83.
- Whitmer DL, Stuck BE. Directed energy (laser) induced retinal injury: current status of safety, triage, and treatment research. *US Army Med Dep J* 2009;51-6.
- Krauss JM, Puliafito CA, Steinert RF. Laser interactions with the cornea. *Surv Ophthalmol* 1986;31:37-53. [Crossref](#)
- Peppers NA, Vassiliadis A, Dedrick KG, et al. Corneal damage thresholds for CO₂ laser radiation. *Appl Opt* 1969;8:377-81. [Crossref](#)
- Alsulaiman SM, Alrushood AA, Almasaud J, et al. High-power handheld blue laser-induced maculopathy: the results of the King Khaled Eye Specialist Hospital Collaborative Retina Study Group. *Ophthalmology* 2014;121:566-72.e1. [Crossref](#)
- Raouf N, Bradley P, Theodorou M, Moore AT, Michaelides M. The new pretender: a large UK case series of retinal injuries in children secondary to handheld lasers. *Am J Ophthalmol* 2016;171:88-94. [Crossref](#)
- Linton E, Walkden A, Steeples LR, et al. Retinal burns from laser pointers: a risk in children with behavioural problems. *Eye (Lond)* 2019;33:492-504. [Crossref](#)
- Dirani A, Chelala E, Fadlallah A, Antonios R, Cherfan G. Bilateral macular injury from a green laser pointer. *Clin Ophthalmol* 2013;7:2127-30. [Crossref](#)
- Bhavsar KV, Wilson D, Margolis R, et al. Multimodal imaging in handheld laser-induced maculopathy. *Am J Ophthalmol* 2015;159:227-31.e2. [Crossref](#)
- Sethi CS, Grey RH, Hart CD. Laser pointers revisited: a survey of 14 patients attending casualty at the Bristol Eye Hospital. *Br J Ophthalmol* 1999;83:1164-7. [Crossref](#)
- Scollo P, Herath G, Lobo A. Retinal injury by industrial laser burn. *Occup Med (Lond)* 2014;64:220-2. [Crossref](#)
- Aras C, Koçluoğlu N, Hasheminia A, Akaydin O. Inadvertent laser-induced retinal injury following a recreational laser show. *Clin Exp Ophthalmol* 2009;37:529-30. [Crossref](#)
- Asiri MS, Alharbi M, Alkadi T, et al. Ocular injuries secondary to alexandrite laser-assisted hair removal. *Can J Ophthalmol* 2017;52:e71-e75. [Crossref](#)
- Brilakis HS, Holland EJ. Diode-laser-induced cataract and iris atrophy as a complication of eyelid hair removal. *Am J Ophthalmol* 2004;137:762-3. [Crossref](#)
- Halkiadakis I, Skouriotis S, Stefanaki C, et al. Iris atrophy and posterior synechiae as a complication of eyebrow laser epilation. *J Am Acad Dermatol* 2007;57(2 Suppl):S4-5. [Crossref](#)
- Crowell EL, Jampel H, Berkenstock M. Alexandrite laser induced uveitis & pigment dispersion: a case report and review of the literature. *Am J Ophthalmol Case Rep* 2020;18:100632. [Crossref](#)
- Yalcindag FN, Uzun A. Anterior uveitis associated with laser epilation of eyebrows. *J Ophthalmic Inflamm Infect* 2013;3:45. [Crossref](#)
- Sheikh A, Hodge W, Coupland S. Diode laser-induced uveitis and visual field defect. *Ophthalmic Plast Reconstr Surg* 2007;23:321-3. [Crossref](#)
- Lin CC, Tseng PC, Chen CC, Woung LC, Liou SW. Iritis and pupillary distortion after periorbital cosmetic alexandrite laser. *Graefes Arch Clin Exp Ophthalmol* 2011;249:783-5. [Crossref](#)
- Gulmez Sevim D, Oner AO, Unlu M, Mirza GE. Ocular complications after cosmetic periocular diode laser application to the eyelids. *J Cosmet Laser Ther* 2018;20:447-8. [Crossref](#)
- Alhalel A, Glovinsky Y, Treister G, Bartov E, Blumenthal M, Belkin M. Long-term follow up of accidental parafoveal laser burns. *Retina* 1993;13:152-4. [Crossref](#)
- Mader TH, Aragones JV, Chandler AC, et al. Ocular and ocular adnexal injuries treated by United States military ophthalmologists during Operations Desert Shield and Desert Storm. *Ophthalmology* 1993;100:1462-7. [Crossref](#)
- Gosling DB, O'Hagan JB, Quhill FM. Blue laser induced retinal injury in a commercial pilot at 1300 ft. *Aerosp Med Hum Perform* 2016;87:69-70. [Crossref](#)
- Yan MK, Kocak E, Yoong K, Kam JK. Ocular injuries resulting from commercial cosmetic procedures. *Clin Exp Optom* 2020;103:430-3. [Crossref](#)
- Huang A, Phillips A, Adar T, Hui A. Ocular injury in cosmetic laser treatments of the face. *J Clin Aesthet Dermatol* 2018;11:15-8.
- Miedziak AI, Gottsch JD, Iliff NT. Exposure keratopathy after

- cosmetic CO₂ laser skin resurfacing. *Cornea* 2000;19:846-8. [Crossref](#)
43. Widder RA, Severin M, Kirchhof B, Krieglstein GK. Corneal injury after carbon dioxide laser skin resurfacing. *Am J Ophthalmol* 1998;125:392-4. [Crossref](#)
 44. Karabela Y, Eliacik M. Anterior uveitis following eyebrow epilation with alexandrite laser. *Int Med Case Rep J* 2015;8:177-9. [Crossref](#)
 45. Parver DL, Dreher RJ, Kohanim S, et al. Ocular injury after laser hair reduction treatment to the eyebrow. *Arch Ophthalmol* 2012;130:1330-4. [Crossref](#)
 46. Shneck M, Levy J, Klemperer I, Lifshitz T. Retinal laser injury during a laser show. *Retin Cases Brief Rep* 2007;1:178-81. [Crossref](#)
 47. Lee GD, Baumal CR, Lally D, Pitcher JD, Vander J, Duker JS. Retinal injury after inadvertent handheld laser exposure. *Retina* 2014;34:2388-96. [Crossref](#)
 48. Tran K, Wang D, Scharf J, Sadda S, Sarraf D. Inner choroidal ischaemia and CNV due to handheld laser-induced maculopathy: a case report and review. *Eye (Lond)* 2020. [Crossref](#)
 49. McCanna R, Chandra SR, Stevens TS, Myers FL, de Venecia G, Bresnick GH. Argon laser-induced cataract as a complication of retinal photocoagulation. *Arch Ophthalmol* 1982;100:1071-3. [Crossref](#)
 50. Lakhnpal V, Schocket SS, Richards RD, Nirankari VS. Photocoagulation-induced lens opacity. *Arch Ophthalmol* 1982;100:1068-70. [Crossref](#)
 51. Herbold TM, Busse H, Uhlig CE. Bilateral cataract and corectopia after laser eyebrow [corrected] epilation. *Ophthalmology* 2005;112:1634-5. [Crossref](#)
 52. Christiansen SP, Bradford JD. Cataract in infants treated with argon laser photocoagulation for threshold retinopathy of prematurity. *Am J Ophthalmol* 1995;119:175-80. [Crossref](#)
 53. Irvine WD, Smiddy WE, Nicholson DH. Corneal and iris burns with the laser indirect ophthalmoscope. *Am J Ophthalmol* 1990;110:311-3. [Crossref](#)
 54. Keithahn MA, Gross RH, Mannis MJ, Morales RB, Morse LS. Corneal perforation associated with argon laser photocoagulation for a retinal tear. *Am J Ophthalmol* 1997;123:125-7. [Crossref](#)
 55. Yeo DC, Osei-Bempong C, Shirodkar A, Williams GS. Foveal haemorrhage from makeshift 'Lightsaber': funduscopy and optical coherence tomography findings. *BMJ Case Rep* 2016;2016:bcr2016214711. [Crossref](#)
 56. Yiu G, Itty S, Toth CA. Ocular safety of recreational lasers. *JAMA Ophthalmol* 2014;132:245-6. [Crossref](#)
 57. Perez-Montano CR, Palomares-Ordóñez JL, Ramirez-Estudillo A, Sanchez-Ramos J, González-Saldivar G. Sub-hyaloid and sub-internal limiting membrane macular hemorrhage after laser exposure at music festival: a case report. *Doc Ophthalmol* 2019;138:71-6. [Crossref](#)
 58. Zhang L, Zheng A, Nie H, et al. Laser-induced photic injury phenocopies macular dystrophy. *Ophthalmic Genet* 2016;37:59-67. [Crossref](#)
 59. Dolz-Marco R, Cunha Souza E, Iida T, et al. Iris atrophy: a novel sign of repeated self-inflicted laser pointer maculopathy. *Retina* 2017;37:e26-e28. [Crossref](#)
 60. Mainster MA, Stuck BE, Brown J Jr. Assessment of alleged retinal laser injuries. *Arch Ophthalmol* 2004;122:1210-7. [Crossref](#)
 61. Dhrami-Gavazi E, Lee W, Balaratnasingam C, Kayserman L, Yannuzzi LA, Freund KB. Multimodal imaging documentation of rapid evolution of retinal changes in handheld laser-induced maculopathy. *Int J Retina Vitreous* 2015;1:14. [Crossref](#)
 62. Shum JW, Iu LP, Cheung DN, Wong IY. A case of accidental ocular injury from cosmetic laser burn. *Retin Cases Brief Rep* 2016;10:115-20. [Crossref](#)
 63. Thach AB. Laser injuries of the eye. *Int Ophthalmol Clin* 1999;39:13-27. [Crossref](#)
 64. Hacker HD, Brown J Jr, Cheramie R, Stuck BE. New approaches to the diagnosis and management of laser eye injury. *Proceeding of SPIE 6426, Ophthalmic Technologies XVII*, 642623. 5 March 2007. [Crossref](#)
 65. Hossein M, Bonyadi J, Soheilian R, Soheilian M, Peyman GA. SD-OCT features of laser pointer maculopathy before and after systemic corticosteroid therapy. *Ophthalmic Surg Lasers Imaging* 2011;42:e135-e138. [Crossref](#)
 66. Lim ME, Suelzer J, Moorthy RS, Vemuri G. Thermal macular injury from a 154 mW green laser pointer. *J AAPOS* 2014;18:612-4. [Crossref](#)
 67. Takahashi K, Lam TT, Fu J, Tso MO. The effect of high-dose methylprednisolone on laser-induced retinal injury in primates: an electron microscopic study. *Graefes Arch Clin Exp Ophthalmol* 1997;235:723-32. [Crossref](#)
 68. Brown J Jr, Hacker H, Schuschereba ST, Zwick H, Lund DJ, Stuck BE. Steroidal and nonsteroidal antiinflammatory medications can improve photoreceptor survival after laser retinal photocoagulation. *Ophthalmology* 2007;114:1876-83. [Crossref](#)
 69. Solberg Y, Dubinski G, Tchirkov M, Belkin M, Rosner M. Methylprednisolone therapy for retinal laser injury. *Surv Ophthalmol* 1999;44 Suppl 1:S85-92. [Crossref](#)
 70. Mtanes K, Mimouni M, Zayit-Soudry S. Laser pointer-induced maculopathy: more than meets the eye. *J Pediatr Ophthalmol Strabismus* 2018;55:312-8. [Crossref](#)
 71. Chen X, Dajani OAW, Alibhai AY, Duker JS, Baumal CR. Long-term visual recovery in bilateral handheld laser pointer-induced maculopathy. *Retin Cases Brief Rep* 2019;10:1097. [Crossref](#)
 72. Robertson DM, McLaren JW, Salomao DR, Link TP. Retinopathy from a green laser pointer: a clinicopathologic study. *Arch Ophthalmol* 2005;123:629-33. [Crossref](#)
 73. Weng CY, Baumal CR, Albin TA, Berrocal AM. Self-induced laser maculopathy in an adolescent boy utilizing a mirror. *Ophthalmic Surg Lasers Imaging Retina* 2015;46:485-8. [Crossref](#)
 74. Turaka K, Bryan JS, Gordon AJ, Reddy R, Kwong HM Jr, Sell CH. Laser pointer induced macular damage: case report and mini review. *Int Ophthalmol* 2012;32:293-7. [Crossref](#)
 75. Schuschereba ST, Bowman PD, Ferrando RE, Lund DJ, Quong JA, Vargas JA. Accelerated healing of laser-injured rabbit retina by basic fibroblast growth factor. *Invest Ophthalmol Vis Sci* 1994;35:945-54.
 76. Zhao N, Liu L. Long-term changes in optic coherence tomography in a child with laser pointer maculopathy: a case report and mini review. *Photodiagnosis Photodyn Ther* 2017;18:264-6. [Crossref](#)
 77. Bernstein PS, Steffensmeier A. Optical coherence tomography before and after repair of a macular hole induced by an unintentional argon laser burn. *Arch Ophthalmol* 2005;123:404-5. [Crossref](#)
 78. Heichel J, Kuehn E, Eichhorst A, Hammer T, Winter I. Nd:YAG laser hyaloidotomy for the treatment of acute subhyaloid hemorrhage: a comparison of two cases. *Ophthalmol Ther* 2016;5:111-20. [Crossref](#)
 79. Gabel VP, Birngruber R, Gunther-Koszka H, Puliafito CA. Nd:YAG laser photodisruption of hemorrhagic detachment of the internal limiting membrane. *Am J Ophthalmol* 1989;107:33-7. [Crossref](#)

80. Dhoot DS, Xu D, Srivastava S. High-powered laser pointer injury resulting in macular hole formation. *J Pediatr* 2014;164:668.e1. [Crossref](#)
81. Petrou P, Patwary S, Banerjee PJ, Kirkby GR. Bilateral macular hole from a handheld laser pointer. *Lancet* 2014;383:1780. [Crossref](#)
82. Thach AB, Lopez PF, Snady-McCoy LC, Golub BM, Frambach DA. Accidental Nd:YAG laser injuries to the macula. *Am J Ophthalmol* 1995;119:767-73. [Crossref](#)
83. Alsakran WA, Alsulaiman SM, Ghazi NG. Delayed spontaneous closure of blue laser-induced full thickness macular hole. *Am J Ophthalmol Case Rep* 2019;13:154-6. [Crossref](#)
84. Alsulaiman SM, Alrushood AA, Almasaud J, et al. Full-thickness macular hole secondary to high-power handheld blue laser: natural history and management outcomes. *Am J Ophthalmol* 2015;160:107-13.e1. [Crossref](#)
85. Qi Y, Wang Y, You Q, Tsai F, Liu W. Surgical treatment and optical coherence tomographic evaluation for accidental laser-induced full-thickness macular holes. *Eye (Lond)* 2017;31:1078-84. [Crossref](#)
86. Safety Guidelines for Laser Products. Electrical and Mechanical Services Department https://www.emsd.gov.hk/en/other_regulatory_services/laser_safety/publications/safety_guidelines_for_laser_products/index.html. Accessed 15 May 2020.
87. Hammes S, Augustin A, Raulin C, Ockenfels HM, Fischer E. Pupil damage after periorbital laser treatment of a port-wine stain. *Arch Dermatol* 2007;143:392-4. [Crossref](#)
88. Bulut MN, Calli U, Goktas E, Bulut K, Kandemir B, Özertürk Y. Use of an intravitreal dexamethasone implant (Ozurdex) in a case with accidental foveal photocoagulation by alexandrite laser. *Case Rep Ophthalmol* 2016;7:130-4. [Crossref](#)