Retinal injury by industrial laser burn

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Abstract

The following case study describes an injury sustained to the fovea of the right eye of a senior engineer engaged in the repair of a neodymium-doped yttrium aluminium garnet (Nd:YAG) laser. Our patient presented with sudden loss of vision in his right eye following accidental exposure to an intense beam of light after the laser’s xenon flash-lamp fired unexpectedly. This accident occurred while the patient was aligning the optical coupler mirror parallel to Nd:YAG laser rod ends using an L-CAT alignment aid. We describe the mechanism of retinal injury, outcome and important issues regarding the safe use of lasers.

Key words

Eye injuries; eye symptoms; occupational injury; ophthalmology.

Introduction

The sensation of light is created when visible wavelengths (400–780 nm) traverse our ocular media and are focused upon the retina to stimulate our photoreceptors. Like visible radiation, infrared A (wavelength: 780–1400 nm) may also be focused upon the retina by the refractive surfaces of the eye but instead of inducing the sensation of light may cause retinal damage. Indeed the optical properties of the eye can increase irradiance by up to a million fold putting the retina at far greater risk of damage from such radiation than any other part of the body [1]. Lasers are internationally classified from 1 to 4; Class 1 being eye-safe and Class 4 being the most dangerous class of laser [2]. Neodymium-doped yttrium aluminium garnet (Nd:YAG) lasers emit light with a wavelength of 1064 nm (infrared radiation) and being classified as Class 4 are capable of causing irreversible eye damage, even if eye exposure is in the form of a diffuse beam reflection. The use of Nd:YAG lasers was first demonstrated in 1964 [3], and they have since been put to use in many fields, including manufacturing, fluid dynamics, military and defence and in medicine. In ophthalmological surgery, Nd:YAG lasers are used to treat posterior capsule opacification, which can develop post cataract surgery and for peripheral iridotomy in closed angle glaucoma. Unfortunately, the increased use of lasers such as the Nd:YAG has meant increased risk of accidental exposure leading to retinal damage.

Case report

A 66-year-old senior engineer engaged in the repair of Nd:YAG lasers presented at eye casualty with a sudden loss of vision in his right eye after accidental exposure to a xenon pump lamp flash the previous day. The laser re-alignment procedure involved the use of the manufacturer's autocollimator ‘L-CAT’, an optical device used to assist in aligning the mirrors adjacent to the end faces of a laser rod. In accordance with the manufacturer’s service manual, the Nd:YAG laser was set to service mode via a mechanical switch, and 230 V power was applied to the laser, providing power to the autocollimator. An important component of the Nd:YAG laser is the xenon flash-lamp, a high power tubular discharge lamp mounted alongside the Nd:YAG laser rod, which on activation excites the Nd:YAG laser rod to emit light at 1064 nm. While aligning the laser’s optical coupler mirror parallel to the Nd:YAG laser rod end using the L-CAT alignment aid, the xenon pump flash-lamp fired unexpectedly causing an intense beam of light to exit the laser cavity and pass through the L-CAT ocular component into our patient’s right eye. On formal assessment, best corrected visual acuity was right 6/60 and left 6/9. Amsler testing revealed a central scotoma in the right eye, and investigation of the fundus revealed a circular greyish patch in the fovea. We informed our patient of the poor visual prognosis but prescribed prednisolone 70 mg orally once daily to be reduced 10 mg every 3 days in the hope that this would hasten the resolution of any macular oedema. Omeprazole 20 mg orally daily was
added to counteract stomach irritation. At 1-week follow-up, best corrected visual acuity remained 6/60 in the right eye. Ishihara score was 17/17 in both eyes. On further fundoscopic examination, a scar was being formed at the fovea of the right macula. At 4-month follow-up, best corrected visual acuity in the right eye remained at 6/60. At a final 18-month follow-up appointment, our patient suffered no further complications but also no further improvement in right eye vision. A macular scar was visible on right eye fundus photography and slit lamp examination with no evidence of choroidal neovascular membrane development. Left eye vision was unchanged. Ocular coherence tomography (OCT), an interferometric technique used to attain high-resolution cross-sectional images of the retina, was performed at all visits (see Figure 1A). Fluorescence angiography was not used as it was not deemed beneficial for diagnosis or treatment.

Discussion

Nd:YAG laser exposure can have a thermal effect on retinal tissue with the potential to damage all layers of Bruch’s membrane. However, the type of laser light is not the only key factor in determining the degree of ocular tissue damage in such cases. Choroidal pigmentation that determines a tissue’s absorption characteristics is also vital and of perhaps the greatest clinical consequence is the location of the injury itself. Previous cases of retinal injury involving Nd:YAG lasers show varying visual acuity outcomes in which some patients improved following the resolution of haemorrhage despite macular hole formation [4], while others showed no visual acuity improvement whatsoever [5]. Others describe improvement in visual acuity only in cases where location of the laser injury was outside the central fovea [6]. Unfortunately, our patient suffered an injury to the fovea and in concordance with these previous findings showed no subsequent improvement in visual acuity. Systemic corticosteroids, the most common treatment for laser retinal injury, were of no apparent benefit to our patient.

Nd:YAG laser beams are normally used in conjunction with ‘aiming’ lasers that emit visible light, for instance, a He–Ne laser (wavelength of 632.8 nm). Should a laser beam accidently enter the eye, the visible beam instigates a blink response thereby limiting exposure time which, once the threshold for tissue damage has been exceeded, becomes the most significant factor in the amount of tissue damage caused. It is, thus, vital that these two lasers are aligned correctly. Increasing industrial laser use carries an increased risk of laser-related injury; indeed some have even reported incidental evidence of unreported retinal damage in those handling lasers [4,7]. The control of the Nd:YAG laser is via dedicated firmware, and while the actual cause of the accidental xenon flash-lamp discharge in this case is not known, a possible cause was a malfunction of the laser control firmware. Prior to the incident involving our patient, during laser re-alignment the Nd:YAG laser had to be powered up to provide power to the autocollimator. This autocollimator has since been modified to run on battery power, allowing the laser to be aligned while disconnected from the mains power ensuring the xenon flash-lamp cannot accidentally fire.

This case also illuminates the importance of simple practical safety issues in laser handling. Regarding safety eyewear, goggles rather than glasses should be worn as injuries have occurred in which laser beams enter the eye beneath glasses [7] and moreover goggles with the correct protective index must be used as patients using argon goggles (designed for wavelength

Figure 1. (A) OCT at 1-week follow-up showing a cross-sectional view of the retina, demonstrating damage to the fovea (circled)—the central area of the macula that is responsible for sharp central vision. Subsequent OCT images showed no resolution of injury. (B) Retinal photograph corresponding with OCT image showing position of injury.
465.99–514.5 nm) for Nd:YAG laser work have also suffered retinal injuries [4].

Key points

- The refractive surfaces of the eye put the retina at far greater risk of permanent damage from laser radiation exposure than any other part of the body.
- Simple practical safety issues such as wearing goggles with the correct protective index, rather than glasses, can help avoid eye injury.
- The avoidance of retinal injury during neodymium-doped yttrium aluminium garnet laser re-alignment can be achieved by modifying auto-collimators so that they run on battery power rather than mains power, thereby precluding the accidental firing of the instrument.

Armadillo

A firmly established tradition of the American Occupational Health Conference is the ‘Britpack’ dinner; the Society of Occupational Medicine hosts a return fixture at the Annual Scientific Meeting. We were in Orlando debating the finer points of the scientific programme when talk turned to golf. Previously the 14th hole on the conference hotel course had boasted an argumentative alligator who was eventually relocated to Gatorland where he lives to this day. Gatorland is worth a visit if only for the bird life and the boardwalk through virgin everglade rather than the bizarre sight of a man wrestling a huge reptile. But my American co-diner Warner said that an even stranger golf hazard was the armadillo. He had hit one once and not only did the ball ping off the hard leathery shell never to be seen again but the animal flew four feet into the air. This is something they do when startled often to impressive and destructive effect under motor vehicles. However Warner continued, and to ensure we could all claim our CPD points with a clear conscience, the armadillo is the cause of an occupational disease. A 2011 study in the New England Journal of Medicine confirmed that armadillos can transmit Mycobacterium leprae to humans. They are the only animals known to carry leprosy due to their low body temperature which provides a good environment for the bacteria and in humans M. leprae prefers cooler areas, such as nostrils, fingers and toes. The armadillo first became a host for leprosy following introduction of the bacteria to South America by European settlers. Leprosy, or Hansen’s disease, named after the Norwegian physician Gerhard Armauer Hansen, is a granulomatous disease of the peripheral nerves and mucosa of the upper respiratory tract; skin lesions are the primary external sign. In the USA, there are 250 cases of leprosy reported each year of which a third are attributable to armadillos. The zoonosis can be contracted as a result of shooting them, eating infected meat or through the shell which is made into a musical instrument by indigenous South Americans and sought after in the USA as a souvenir. The occupational link is in those who handle them through farming or research work. Mycobacterium leprae is extremely hard to grow and for that reason the armadillo is used in research laboratories although laboratory workers are adequately protected if they have had the BCG vaccination. Diagnosis in the USA is often delayed because health-care providers are unaware of leprosy and its symptoms. Early diagnosis and treatment prevents nerve involvement and the disability it causes. Left untreated, leprosy can be progressive, causing permanent damage to the skin, nerves, limbs and eyes. Worldwide, 2–3 million people are estimated to be permanently disabled because of leprosy. Even though global incidence is now falling, in 2000, the World Health Organization (WHO) listed 91 countries in which Hansen’s disease was endemic with India, Burma and Nepal containing 70% of cases. The things you learn at conferences.

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References