

# Laser Pointer Retinal Injuries

Injury from laser pointer trauma is a public health problem on the rise.

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In the past few years, injuries or incidents involving accidental or intentional laser pointer exposure have been on the rise, and these events are now becoming dangerously common. The media has reported several instances of intentional laser exposure of professional and collegiate athletes during prominent events such as FIFA World Cup and National Football League games.<sup>1,2</sup> Fans who intentionally expose athletes to laser radiation are usually unfamiliar with the potential damage that these devices can cause to the eye.

In January, the US Federal Aviation Administration (FAA) released a spreadsheet detailing incidents from 2010 to 2014 in which lasers were directed from the ground at aircraft.<sup>3</sup> In 2014 alone, there were 3894 incidents, a 2.4% decline from 2013, the year when the US Federal Bureau of Investigation and the FAA began campaigning to deter incidents by imposing criminal sentences and fines and offering rewards of up to \$10 000 for information leading to arrests of people intentionally shining lasers at aircraft. Perhaps the most publicized case was that of a man from California who was sentenced to a 14-year prison sentence for shining a high-powered laser at an emergency transport helicopter for Children's Hospital of Central California.<sup>4</sup>

However, despite the campaign to increase public education and impose punishments for these felonies, the volume of laser incidents with aircraft has continued to increase, from 46 in 2004 to more than 3000 per year since 2010.

Perhaps the greatest concerns are raised by reports of unsupervised children who have received these lasers as toys or gifts and expose themselves to the laser beams, causing permanent retinal injury with reduced central vision (Figure). From 2000 to 2009, there were five reports of 18 patients with injuries due to laser pointer exposure.<sup>5,6</sup> Over the past 4 years there has been a sharp rise in the number of reported laser pointer injuries in children, with at least 36 identified by a Pubmed search (search terms: retina, laser injury, laser pointer). The vast majority of cases involved males younger than age 18 years, including

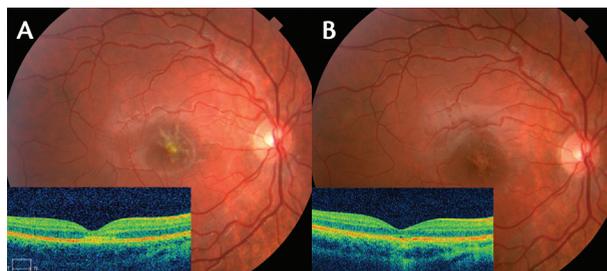


Figure. Color fundus photograph and corresponding optical coherence tomography scan through the fovea of the right eye of a 9-year-old patient at initial presentation 3 days after laser injury (A) and 1 year after laser injury (B). The laser in this case was a red 654 nm handheld laser of 121 mW power.

one child as young as 9 years.<sup>6,7</sup> The injuries were typically sustained by staring directly at the laser pointer beam, by staring at a laser pointer beam reflected off a mirror, or by being exposed by another person.

## TYPES OF INJURY

Lasers can cause a variety of types of retinal injuries depending on the power and wavelength of emission.<sup>8</sup> The power (energy delivered) and duration of laser exposure are the two major determinants of whether injury to the retina occurs and, if so, the extent of injury.

Lasers employ three mechanisms capable of damaging retinal tissue: thermal, photochemical, and mechanical. Thermal photocoagulation is typically the mode of action of lasers used in the clinic for panretinal photocoagulation, such as argon and krypton lasers. The energy from these lasers is transferred to the pigment of a cell, and a resulting rapid increase in temperature causes protein denaturation and cell death. Photochemical damage occurs when a laser's optical radiation causes phototoxic chemical reactions, again resulting in cell death. The same type of damage is seen from solar retinopathy or exposure to arc welding. Mechanical damage may occur when a laser's energy absorption takes place over a short pulse duration and

there is creation of a plasma and water vaporization, leading to tissue disruption. Nd:YAG lasers use the mechanism of mechanical disruption in the treatment of certain ocular conditions.

### **DISTINGUISHING POINTERS FROM 'HANDHELDS'**

The American National Standards Institute (ANSI) is the body that regulates lasers manufactured and sold in the United States. ANSI requires that lasers marketed and sold as "laser pointers" be in class 3A, which encompasses lasers of 1 to 5 mW or less of power. This means a laser pointer can have a maximum power of 5 mW and a wavelength between 400 and 700 nm. The US Food and Drug Administration (FDA) describes class 3A lasers as being hazardous if the beam is viewed directly, even momentarily.

Another category, "handheld" lasers, can be more powerful: either class 3B (5-500 mW) or class 4 (> 500 mW), and these lasers may cause immediate skin and eye hazard when viewed directly, according to the FDA.

In other words, any laser with a power greater than 5 mW has the potential to immediately and negatively impact vision when viewed directly. Unfortunately, "handheld" lasers greater than 5 mW are readily available through websites from distributors in Asia. A Google search for "high-powered laser pointer" returns many websites selling so-called "laser pointers" rated at up to 2000 mW of power. This is 400 times more powerful than a 5-mW laser, the FDA's top limit for laser pointers. A 2000-mW laser is capable of popping a balloon or melting plastic from up to 50 feet away.

Also unfortunate is that high-powered class 3B handheld lasers can look identical to laser pointers of less than 5 mW of power. It may therefore be impossible for parents to understand the dangers a laser poses to their children. That is, of course, unless they understand what the power listed on the device signifies, which most parents—and most physicians, for that matter—do not. Some of the most powerful handheld lasers resemble weapons and are required to come with a key switch to activate the laser, but many class 3B lasers come without a key switch and resemble any laser pointer used in a classroom.

Even if a laser is labeled with its power output, as required by the FDA, the product's actual specs often do not agree with its labeling. A study measuring the power of 122 laser pointers labeled as class 3A (1-5 mW) found that 44% of red laser pointers and 90% of green laser pointers tested had power outputs greater than 5 mW.<sup>9</sup> Moreover, some green handheld lasers pointers create a 532 nm wavelength by using an infrared 1064-nm Nd:YAG crystal. Unless the laser has an infrared filter, some 1064-nm radiation will escape the laser and be present in conjunction with the 532-nm

green light. Infrared light is not part of the visual spectrum. There is no aversion response when one looks at infrared light, and this results in longer durations of exposure to harmful radiation and greater potential for retinal injury.

### **LOCATIONS OF RETINAL INJURY**

Laser pointers of different colors cause injury in different locations in the retina.<sup>8</sup> Green lasers result in damage to the retinal pigment epithelium (RPE) and outer retina because their 532-nm wavelength is absorbed in melanin granules in RPE cells. Red lasers may cause similar RPE changes but require longer durations of exposure. However, case reports of red laser exposure have often involved devices with less power (class 3A or low-end class 3B) rather than shorter durations when compared with green laser injuries.<sup>10</sup>

Blue and violet lasers introduced to the market recently are alarmingly high-powered, up to 1000 to 2000 mW. Alsulaiman et al reported 14 blue laser injuries in a span of 1 year in Saudi Arabia, causing the development of full thickness macular holes or prehyaloid hemorrhages with dense epiretinal membrane formation.<sup>11</sup> The blue wavelength may focus more anteriorly in the retina due to its shorter wavelength and cause damage to the vitreoretinal interface, resulting in the pathologies reported.

Reports of long-term visual outcomes of injuries due to high-powered lasers rated as class 3B or higher have observed good visual acuity prognosis after a period of days to months unless the injury involves the fovea, in which case vision is permanently reduced.<sup>6,11</sup> In the acute setting, optical coherence tomography (OCT) in eyes with laser damage shows outer photoreceptor disruption, with hyperreflective bands extending from the outer photoreceptors to the Henle layer.<sup>6,12</sup> Over time, outer hyporeflexive spaces can develop in areas of photoreceptor loss and RPE irregularity, evolving to focal atrophy. Choroidal neovascularization may also occur, leading to reduced central vision.<sup>13,14</sup>

### **CONCLUSIONS**

Inappropriately used class 3B or 4 lasers should be considered weapons that can cause serious, permanent bodily injury. Even brief exposures to diffused rays of laser beams can cause temporary flash blindness that may last for hours in airline pilots, endangering the lives of passengers, particularly during takeoff and landing sequences. Cases of short-range laser exposure are becoming more common, often involving children who are inappropriately given these devices as toys, and these patients are referred to retina specialists after the damage has already occurred.

No definitive experimental study, case report, or animal model has shown improvement in these injuries with any type of treatment, but typically these patients are treated with a short course of corticosteroids or nonsteroidal

antiinflammatory drugs. Secondary choroidal neovascularization has been treated successfully with intravitreal anti-VEGF agents.<sup>13,14</sup>

Clinicians, particularly retina specialists, can raise awareness of this rising public health issue by educating patients and parents about the hazards of laser pointers. Legislation is currently being written to impose stronger regulations on the distribution and sale of these devices. If a patient presents with findings of a laser-related retinal injury, clinicians should report the incident to the FDA so that investigations can be performed into the manufacturers of these devices. Reports can be made at [www.fda.gov/downloads/AboutFDA/ReportsManualsForms/Forms/UCM236066.pdf](http://www.fda.gov/downloads/AboutFDA/ReportsManualsForms/Forms/UCM236066.pdf).

Valuable information, updates, and case reports germane to this issue can be found at the independent website [laserpointersafety.com](http://laserpointersafety.com). ■

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