Laser Eye and Skin hazards

Structure of eye

The potential for injury to the different structures of the eye depends upon which structure absorbs the energy and any repair processes that may exist for that structure.

Cornea

The cornea serves two functions:

- Performs the initial focusing
- Protects various internal structures from the environment

The cornea is constantly exposed to the environment. For this reason it is constantly regenerated every 48 hours. Therefore, damage to this layer of the eye is usually repairable.

Lens

The lens is the main refractive tissue in the eye which focuses images on to the retina. Damage to the proteins that comprise the lens will result in cloudiness often referred to as a cataract. There is no repair mechanism for the lens, once it has been damaged it must be replace surgically.

Retina

The retina is the receptor organ for light focused on it by the lens. It consists of non-repairable specialized nerve tissue. Damage to parts of this tissue will result in permanent blindness or blind spots.
Ocular image

Wavelengths between 400 nm and 1400 nm are focused by the curved cornea and lens on to the retina. The optical gain is about 100,000-200,000 times. Viewing a laser beam or point source will focus all the light on a very small area of the retina, resulting in a greatly increased power density and an increased chance of damage.

A large source of light such as a diffuse reflection of a laser beam produces light that enters the eye at a large angle is called an extended source. An extended source produces a relatively large image on the retina and energy is not concentrated on a small area in the retina as in a point source.

Details of irradiation effects on eyes

Coronal effects

Ultraviolet-B+C (100 - 315 nm)

The surface of the cornea absorbs all UV of these wavelengths which produce a photokeratitis (weld flash) by a photochemical process which cause a denaturating of proteins in the cornea. This is a temporary condition because the corneal tissues regenerate very quickly.

Infrared-B and Infrared-C (1400 nm to 1.0mm)

Corneal tissue will absorb light with a wavelength longer than 1400 nm. Damage to the cornea results from the absorption of energy by tears and tissue water causing a temperature rise and subsequent denaturation of protein in the corneal surface.
Lens effects

The lens absorbs Ultraviolet radiation of these wavelengths.

Photochemical processes denature proteins in the lens resulting in the formation of cataracts.

Retinal effects

Visible light and Infrared-A (400 - 1400 nm)

The cornea, lens and vitreous fluid are transparent to light of these wavelengths but it is absorbed by retinal tissue.

Damage to the retinal tissue occurs by absorption of light and its conversion to heat by the melanin granules in the pigmented epithelium or by photochemical action to the photoreceptor. The focusing effects of the cornea and lens will increase the irradiance on the retina by up to 100,000 times. For visible light 400 to 700 nm the aversion reflex which takes 0.25 seconds may reduce exposure causing the subject to turn away from a bright light source. However this will not occur if the intensity of the laser is great enough to produce damage in less than 0.25 sec. or when light of 700 - 1400 nm (near infrared) is used as the human eye is insensitive to these wavelengths.

Skin related effects

Laser radiation effects on skin

Skin effects are generally considered of secondary importance except for high power infrared lasers. However with the increased use of lasers emitting in the ultraviolet spectral region, skin effects have assumed greater importance.

Erythema (sunburn), skin cancer and accelerated skin aging are produced by emissions in the 200 to 280 nm range. Increased pigmentation results from exposure to light with wavelengths of 280 to 400 nm. Photosensitization has resulted from the skin being exposed
to light from 315 to 700 nm. Lasers emitting radiation in the visible and infrared regions produce effects that vary from a mild reddening to blisters and charring.

These conditions are usually repairable or reversible however depigmentation, ulceration, and scarring of the skin, and damage to underlying organs may occur from extremely high powered lasers.

Summary of wavelengths of light and their effects on tissues

Below is a summary of the interaction of optical radiation and various tissues.

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