Visual Impairments  
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It is estimated that 40 percent of the central nervous system relates to visual function, either directly through gathering and assessing visual images or indirectly through control of eye movements. Because of this rich innervation, traumatic and other insults to the head and brain often result in temporary or permanent visual impairment, either from injury to the eye or eyes directly or secondarily through brain injury. Vision is exceedingly important to independent functioning, thus severe impairments can greatly impact a person's ability to live independently, let alone earn a livelihood. This reading assignment will explore specific examples of injuries or other occurrences which can cause visual impairment, demonstrate how visual impairment is formally assessed, and discuss ways in which partially sighted patients can be assessed to lead fuller lives.

Ocular Injuries

There are many circumstances in which the eyes can be injured. Many common injuries can be expected to resolve completely with proper therapy, such as corneal abrasion (rubbing off the front surface of the eye or cornea), while others will result in permanent visual disability, and at times, the loss of an eye. Industrial eye injuries such as metallic foreign bodies from hammering nails can often be prevented with the use of safety glasses, but, unfortunately, these are not always worn by those at risk. In general, accidental eye injuries result from three mechanisms:

1. Chemical splash
2. Blunt trauma
3. Penetrating foreign body

The eye can also be injured as part of a general facial or head injury, such as a crush injury or electrocution/lightning injury. These will be examined separately below.

Chemical Splash Injuries

Chemical splash injuries are probably the most common ocular injury, and fortunately are usually appropriately treated with good outcome. Personnel at any emergency room or urgent care center will irrigate the affected eye immediately (the most appropriate initial treatment), and if the cornea remains clear by microscopic exam (the slit lamp), simply patching the affected eye will result in healing of the corneal epithelium which may have been eroded by the chemical. Such injuries may be quite painful acutely, but heal in several days. Very rarely such an injury can result in "recurrent erosions" or a situation in which the corneal epithelium continues to slough off occasionally. Even when this happens, it can generally be successfully treated with drops or contact lenses without long-term disability.
A much more ominous situation occurs with chemical splashes with either metallic acids like that in a car battery, or much worse, strong alkalais with commonly available sources being potash, lye, and oven cleaner. These substances can cause opacification of the cornea, but also scarring of the conjunctiva, which is the skin surface of the eyeball itself and inner side of the eyelids. This can produce distortion of the eyelids and eye with inadequate closure of the lids, and thus, lack of moisture and decreased protection of the eye occurs. Although corneal transplant can sometimes be offered to these patients, these transplants often fail and result in opacity secondary to the abnormalities of the conjunctiva and eyelid position and function. If both eyes are involved with this type of chemical splash, visual impairment may be profound and accompanied by ocular pain. These are the most serious chemical injuries to the eyes.

**Blunt Trauma Injuries**

Blunt trauma to the eyes is also common, either on the job or in recreational settings, i.e. a fist or baseball to the eye. If the object causing the trauma is fairly large, the bones around the eye will often limit the impact to the globe itself, however, in the case of small or deformable balls, like a tennis or racquet ball or the knuckles of a fist, the trauma to the eye will often be considerable and can result in immediate bleeding into the anterior and/or posterior part of the eye. Anterior bleeding (into the space between the cornea and the iris or colored part of the eye) is called a hyphema. Bleeding into the posterior segment (behind the lens) is called a vitreous hemorrhage. Each can usually be managed conservatively with resolution, but at times the blood will need surgical removal. In each case the bleeding is a symptom that the trauma was fairly severe. Such eyes can develop cataract (opacity and/or hardening of the lens) either immediately or in the distant future, but sooner than the other non-traumatized eye. These eyes can also develop glaucoma, (raised pressure which results in damage to the optic nerve and visual field) and/or retinal detachment (a separation of the nerve in the back of the eye from its nourishing blood vessels). Although all of these conditions can usually be treated, the trauma itself can make the treatment less than 100 percent effective. A traumatized eye may have abnormal anatomy, such as a dislocated lens (which has lost some of its normal attachments in the eye), which can make even what is usually very safe and effective cataract surgery (removal of the lens) less predictable in terms of visual outcome. Also, glaucoma in traumatized eyes can be very difficult to control and can go on to cause visual loss in spite of therapy with eye drops and/or surgery. Although retinal detachments can usually be repaired surgically, visual results are not always perfect, especially if the eye has been traumatized. Ongoing, yearly eye examinations should be performed in any eye with a history of blunt trauma even without the patient reporting symptoms or known visual impairment initially.

**Penetrating Foreign Body Injuries**

The most devastating injury to an eye is that with penetration of the cornea or sclera (eye wall). Once an object (usually sharp) has partially penetrated the eye,
such injuries often cause tears in the cornea, lens, and retina since the eye structure is not rigid enough to limit its track, thus even though surgical repair (suturing) of corneal laceration, lens removal, and sealing a retinal tear may be possible, good functional outcome with good return of visual acuity may not be realized. Such eyes often develop glaucoma and can even go on to a condition called ptosis in which the eye withers and becomes blind.

Any eye that becomes blind, or nearly blind, and is painful is a candidate for enucleation or surgical removal of the eyeball itself. If the eye is phthisical and unsightly, enucleation can result in an improved cosmetic appearance as the oculist who creates the artificial eye strives to make an exact cosmetic match to the remaining good eye. With properly done enucleation surgery, the artificial eye can have good eye movement so that to most observers the result is natural appearing.

Any patient who sustains a significant ocular injury should be examined and followed up by an eye professional. Although corneal abrasions generally heal without permanent visual impairment, blunt trauma to the eye and/or penetrating injuries are more likely to lead to permanent visual impairment or development of complications such as cataract or glaucoma even years later. Such eyes need yearly eye examinations indefinitely. Acid and alkalai injuries can likewise result in severe and permanent impairment.

**Brain Injury**

As previously stated, approximately 40 percent of the central nervous system influences vision or alignment of the eyes (eye movement), thus brain injury is an important cause of visual impairment. Such injury can result from "natural disasters" such as stroke, brain tumors, or multiple sclerosis, but also from head trauma typically from motor vehicle accidents, and industrial accidents. Injuries can occur to the optic nerve, which connects the eye to the brain, and to visual fibers in the head to the occipital lobes, where vision is interpreted. The nerve fibers, which come to the muscles of the eye and give them the orders to move or synchronize can also be impacted. These injury types are discussed separately below.

First, the optic nerve can be damaged by head trauma. This nerve exits the eye, travels through the orbit – an inverted cone-shaped structure behind the eye bounded by bones, then through a bony canal to get into head. The optic nerve can be directly traumatized by a penetrating injury to the orbit, such as a suicide attempt with gunshot wound through the temples. If the nerve is entirely transected (cut in half), unremedial blindness results. Often the nerve is indirectly traumatized by a blow to the brow area, which results in a telescoping-type injury of the optic nerve in the optic canal, which strips the nerve of its blood supply. Such injuries can seem almost trivial, but nevertheless result in severe permanent visual impairment.

Behind the optic canal, both optic nerves merge into an area called the optic chiasm. The nerve fibers then rearrange themselves so that as they exit the
chiasm posteriorly, all nerve fibers from each eye that see to the right of the center go to the left half of the brain, eventually to end at the left occipital lobe where vision is interpreted. This situation is reversed for all fibers to the left of center. It is possible for the chiasm to be traumatized especially with injuries, which result in basilar skull fractures. Injury to the chiasm commonly results in visual field defects (peripheral vision loss), not loss of sharpness of vision (visual acuity). If brain injury or insult is further back in the head, visual nerve fibers which are traveling back to the occipital lobes can be damaged. Again, usually a visual field defect will result, except for the rare situation of insult to both right and left brain simultaneously. If the occipital lobe is involved, a visual field defect called homonymous hemianopia will result in which the patient cannot see anything to the left of center with either eye if the right exit lobe is affected, and vice versa for the left occipital lobe. Total blindness can result from bilateral occipital lobe insult such as bilateral stroke or posterior head trauma.

Ocular alignment depends on intact pathways in many parts of the brain and brainstem, which is located at the base of the skull and back of the head. Most significant impairments of eye movements involve one or more of the three nerves which go to muscles of each eye to "order" the muscles to move and synchronize. These nerves arise in the brainstem and pass through the brain to the orbits. There are many ways in which these nerves can be damaged. Often closed head trauma will result in nerve palsy (weakness) from stretching or bruising of such a nerve. Surgery in the posterior part of the brain or base of brain can also result in bruising or other damage to these nerves, and result in a complaint of double vision. Sometimes these palsies are temporary, but at other times they lead to permanent misalignment of the eyes.

Patients with double vision from ocular misalignment may be helped in a variety of ways. If the double images are fairly close and about the same distance apart in any direction in which the patient looks, prisms in glasses to move one image to merge with the other can often be 100 percent effective. If the patient has differing amounts of separation of images depending on where he looks, prisms may still help especially in straight ahead or down gaze, which are the two most important positions of gaze for adults. This patient may still, however, experience double vision in other positions such as when looking right, left, or up. If the images are far apart, generally, eye muscle surgery will be recommended, but the results can be variable. Usually this surgery, which simply moves the eye muscle to different positions of attachment on the eye itself, cannot completely overcome the effect of a "dead" nerve to one or more eye muscles. Often, the best result obtainable is elimination of double vision in straight ahead and down-gaze.

Some patients with double vision will not do well with prisms or surgery, perhaps because one image is tilted or too many eye muscles are unable to move because of lack of nerve control. Generally, every patient with double vision can avoid seeing two images by simply patching or blocking the vision of one eye. This can be accomplished with an occluder over one glasses lens or even scotch tape in one of the glasses lenses. However, many patients are uncomfortable with this solution because of the restriction of vision, lack of binocular vision in any position and/or embarrassment at covering one eye continuously. Patients
who have double vision within 20 degrees of fixation (straight ahead) are considered to have 100 percent ocular impairment for one eye. This is taken into account when performing any impairment ratings for medical, legal, or any other purposes (see below calculating visual impairment).